ACTIVITIES OF THE WATER RESOURCES DIVISION CALIFORNIA DISTRICT, FISCAL YEAR 1994

Compiled by Myrna L. DeBortoli

U.S. GEOLOGICAL SURVEY

Open-File Report 95-150

Sacramento, California
1995

U.S. DEPARTMENT OF THE INTERIOR
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MESSAGE FROM THE DISTRICT CHIEF

The water-resource programs described in this report have been developed to specifically address the mission of the California District, Water Resources Division (WRD), U.S. Geological Survey (USGS).

The mission of the USGS, WRD, California District, is to provide unbiased scientific information of the highest quality to decision makers and the public to aid in the responsible planning, use, and management of California's water resources. Within the framework of the national WRD mission, the California District, in cooperation with local, State, and other Federal agencies, is committed to the collection, interpretation, and dissemination of timely and accurate information to address water-resources issues.

To help focus on our mission and to help the more than 120 cooperating water agencies in California, the California District has established the following goals:

TO CONTINUOUSLY ADVANCE THE QUALITY AND RELEVANCE OF EARTH SCIENCE

In the California District, program plans include projects that specifically attempt to increase the level of understanding in the hydrologic sciences while providing solutions to difficult water issues. As examples, projects that demonstrate this are "Processes Governing the Distribution and Mobility of Selenium and Arsenic in Shallow Ground Water, Tulare Basin" (CA481), "Environmental fate of 1,2-dibromo-3-chloropropane, San Joaquin Valley" (CA507), "Ground-water and surface-water relations along the Mojave River" (CA497), and "Denitrification, attenuation of organic compounds, and colloid transport beneath a reclaimed-water artificial recharge system" (CA498).

TO PROVIDE RELEVANT SCIENTIFIC INFORMATION THAT ADDRESSES CUSTOMER NEEDS WITHIN THE SCOPE OF OUR MISSION

The collection and interpretation of hydrologic data must be done to better understand natural hydrologic processes. The results are used by water managers throughout the State to solve water-related problems. The surface-water (CA001) and ground-water (CA002) data-collection programs provide relevant information that is used to resolve critical water problems statewide. The information that is being provided as part of the Southern California RASA (CA424) project can be directly applied to water issues along the South Coast and the Mojave Desert. The National Water-Quality Assessment (NAWQA) programs in the Sacramento (CA504) and San Joaquin (CA485) basins are providing valuable information on surface- and ground-water quality, which is of great importance to water managers in these water-dependent areas.

TO INCREASE PUBLIC KNOWLEDGE OF WATER-RELATED EARTH SCIENCE AND AWARENESS OF OUR PROGRAMS AND ACTIVITIES

The release of this report and others on our Worldwide Web (WWW) Home Page (http://s101dcascr.usgs.gov) is an example of new, innovative approaches that the California District is using to distribute the large amounts of water information generated within our programs. We have instituted new processes that will allow information to reach larger audiences more quickly. We are committed to providing high-quality reports that are understandable and helpful to a larger audience.

The California District staff is dedicated to accomplishing its mission to study and describe California's water resources. I welcome any comments or suggestions that you, the users of our information, might have to help us improve in this area. Please feel free to contact me directly at (916) 979-2605, send E-mail to Shulters@dcascr.wr.usgs.gov, or write to

Michael V. Shulters
District Chief
U.S. Geological Survey, Water Resources Division
2800 Cottage Way, Room W-2233
Sacramento, CA 95825

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U.S. GEOLOGICAL SURVEY ORIGIN

The U.S. Geological Survey (USGS) was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to conduct the systematic and scientific "classification of the public lands, and examination of the geological structure, mineral resources, and products of national domain." An integral part of that mission includes publishing and disseminating the earth-science information needed to understand, to plan the use of, and to manage the Nation's energy, land, mineral, and water resources.

Since 1879, the research and factfinding role of the USGS has grown and been modified to meet the changing needs of the Nation. As part of that evolution, the USGS has become the Federal Government's most comprehensive earth-science research agency, the Nation's largest civilian mapmaking agency, and the primary source of data on the Nation's surface- and ground-water resources. Today's programs serve a diversity of needs and users. Programs include

- Assessing the energy and mineral potential of the Nation's land and offshore areas.
- Geological risk assessment, including issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.
- Conducting research on the tectonics of the Earth.
- Studying the geologic features, structure, processes, and history of the other planets of our solar system.
- Conducting topographic surveys and preparing topographic and thematic maps and related cartographic products.
- Developing and producing digital cartographic data bases and products.
- Collecting data on a routine basis to determine the quantity, quality, and use of surface and ground water.
- Conducting water-resource appraisals in order to provide accurate scientific information so that responsible officials may describe the consequences of alternative plans for developing land and water resources.
- Conducting research in ground- and surface-water hydrology and hydraulics and coordinating water-data acquisition with other Federal agencies.
- Using remotely sensed data to develop new cartographic, geologic, and hydrologic research techniques for natural-resources planning and management.
- Providing earth-science information through an extensive publications program and a network of public-access points.

Along with its continuing commitment to meet the growing and changing earth-science needs of the Nation, the USGS remains dedicated to its original mission to collect, analyze, interpret, publish, and disseminate information about the natural resources of the Nation--providing "Earth science in the public service."

WATER RESOURCES DIVISION BASIC MISSION AND PROGRAM

The mission of the Water Resources Division (WRD) is to provide the hydrologic information and understanding needed for the optimum use and management of the Nation's water resources. To accomplish this mission, the WRD, in cooperation with local, State, and Federal agencies, uses a wide variety of techniques to collect and interpret hydrologic information and to transfer that information to the water-user community. An integral part of that mission includes publishing and disseminating the earth-science information needed to understand, plan the use of, and manage the Nation's energy, land, mineral, and water resources.

This is accomplished, in large part, through cooperation with other Federal and non-Federal agencies, by

- Systematically collecting data needed for evaluating the quantity, quality, and use of the Nation's water resources.
- Conducting analytical and interpretive water-resources appraisals of the occurrence, movement, and water-quality characteristics of surface and ground water.
- Conducting basic and applied research in hydraulics, hydrology, and water chemistry, solute transport, and hydraulic modeling to improve the scientific basis for investigations and measurement techniques and to understand hydrologic systems sufficiently well to quantitatively predict their response to stress, either natural or manmade.
- Disseminating the water data and the results of these investigations and research through reports, maps, computerized information services, and other forms of public releases.
- Coordinating with other Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries, and aquifers.
- Providing scientific and technical hydrologic assistance to other Federal, State, and local agencies, to licensees of the Federal Energy Regulatory Commission, and to International agencies on behalf of the Department of State.

CALIFORNIA DISTRICT ORGANIZATION

The headquarters for the California District is in Sacramento. Hydrologic investigations and data collection during fiscal year 1994 were done from 2 project offices (Sacramento and San Diego) and 7 field offices and one unmanned field-support site in Eureka. These offices and supporting units are shown in the District organization chart (fig. 1). The location of each office is shown in figure 2.

U.S. GEOLOGICAL SURVEY
California District

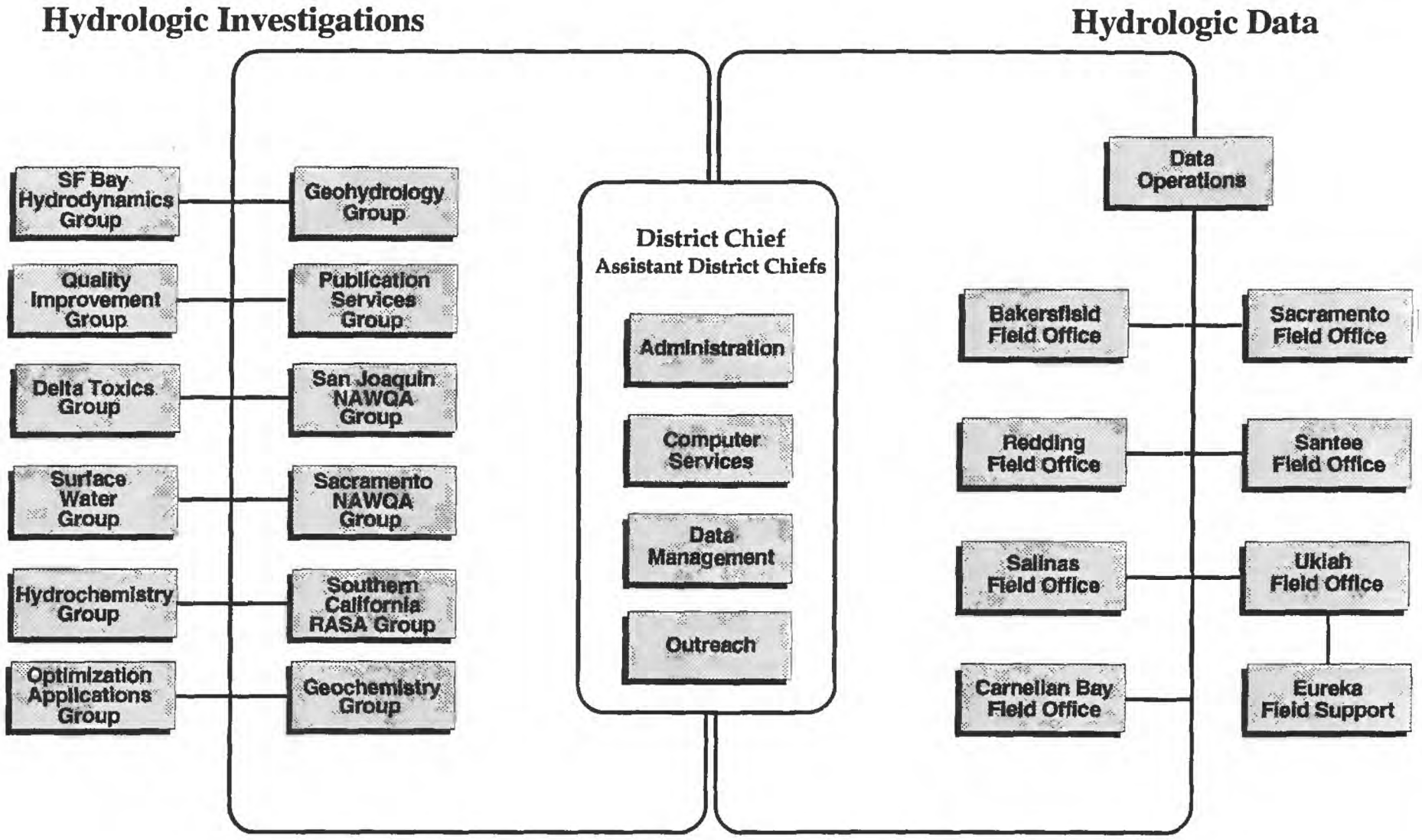

Figure 1. Organization chart for the California District, 1994.

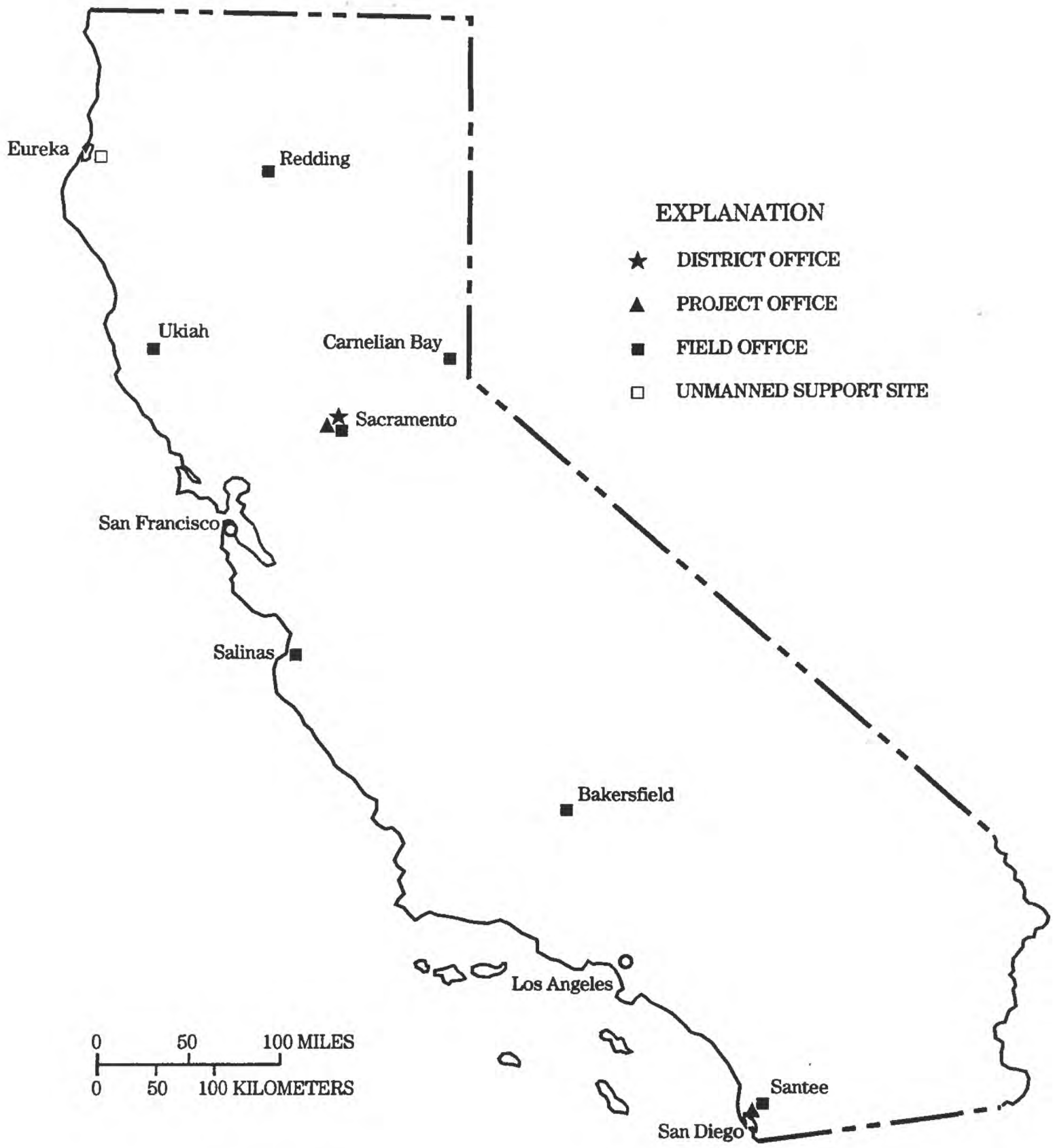

Figure 2. Location of offices in the California District, 1994.

CALIFORNIA DISTRICT ADDRESSES

Inquiries regarding projects described in this report may be directed to the District Office. Addresses for the offices of the District Chief and Assistant District Chiefs and Field Office Chiefs are listed below. Location of offices are shown in figure 2.

DISTRICT CHIEF

Michael V. Shulters District Chief	(916) 979-2605 ext. 342	U.S. Geological Survey 2800 Cottage Way, Rm W-2233 Sacramento, CA 95825

ASSISTANT DISTRICT CHIEFS

Gilbert L. Bertoldi Assistant District Chief	(916) 979-2615 ext. 362	2800 Cottage Way, Rm W-2233 Sacramento, CA 95825
Anthony Buono Assistant District Chief	(619) 637-9005	5735 Kearny Villa Road Suite O San Diego, CA 92123
F.J. Heimes Assistant District Chief	(916) 979-2650 ext. 313	2800 Cottage Way, Rm W-2233 Sacramento, CA 95825

FIELD OFFICE CHIEFS

Bakersfield Paul D. Hayes	(805) 861-4347	3131 Pegasus Drive Bakersfield, CA 93308
Carnelian Bay Gerald Rockwell	(916) 546-0187	5229 North Lake Boulevard P.O. Box 1360 Carnelian Bay, CA 96140
Redding Michael F. Friebel	(916) 246-5282	11075 Black Marble Way Redding, CA 96003
Sacramento Steven W. Anderson	(916) 979-3025 ext. 323	3419-A Arden Way Sacramento, CA 95825
Salinas Larry F. Trujillo	(408) 754-6717	1636 East Alisal Street Salinas, CA 93905 P.O. Box 5027 Salinas, CA 93915
Santee Jeffrey Agajanian	(619) 557-5155	10130 Mission Gorge Road Santee, CA 92071
Ukiah Kenneth L. Markham	(707) 462-2794	1240 Airport Park Boulevard Ukiah, CA 95482

CALIFORNIA DISTRICT FUNDING

Programs of the Water Resources Division in California are funded by (1) Federal appropriations to the Geological Survey by Congress; (2) Federal and State cooperation, in which the Water Resources Division represents national interest and the cooperating agencies represent State and local interest with shared funding (the Federal share comes from direct Congressional appropriations); and (3) other Federal agencies (OFA). Total funds and sources of funding for fiscal year 1994 are shown in figure 3. [The fiscal year (FY) is from October 1 to September 30 and is designated by the calendar year in which it ends.]

Funding percentages for investigations for fiscal year 1994 in each of the broad categories of hydrologic-data collection, areal appraisals and interpretive studies, and research projects are shown in figure 4.

In fiscal year 1994, the following State, local, and Federal agencies contributed funds and services under cooperative programs with the California District:

State Agencies

California Department of Conservation
California Department of Fish and Game
California Department of Parks and Recreation
California Department of Water Resources
California State Water Resources Control Board
California Regional Water Quality Control Board
Central Valley Region
San Francisco Bay Region

Local Agencies

Alameda County Flood Control and Water Conservation District
Alameda County Water District
Antelope Valley-East Kern Water Agency
Atherton, city of
Calaveras County Water District
Carpenteria County Water District
Casitas Municipal Water District
Coachella Valley Water District
Contra Costa County Flood Control and Water Conservation District
Contra Costa Water District
Desert Water Agency
East Bay Municipal Utility District
Eastern Municipal Water District
Energy Growth Partnership
Five Bears Hydroelectric
Georgetown Divide Public Utility District
Goleta County Water District
Highland Hydro Constructors
Hoopa Valley Tribe
Hopland Band of Pomo Indians
Humboldt Bay Municipal Water District

Local Agencies--*Continued*

Imperial County Department of Public Works
Imperial Irrigation District
Independent Hydro Developers
Lassen Station Hydroelectric
Lompoc, city of
Los Angeles County Department of Public Works
Louisiana State University and A&M College
Madera Irrigation District
Malacha Power Project
Marin Municipal Water District
Mendocino County Water Agency
Merced, city of
Merced Irrigation District
Mojave Water Agency
Mono County
Montecito Water District
Monterey County Water Resources Agency
Monterey Peninsula Water Management District
Morongo Band of Mission Indians
Nelson Creek Power Company
Nevada Irrigation District
Oakdale-South San Joaquin Irrigation District
Olcese Water District
Orange County Water District
Oroville-Wyandotte Irrigation District
Pacific Gas & Electric Company
PacificCorp
Pechanga Indian Reservation
Placer County Water Agency
Riverside County Flood Control and Water Conservation District
Rock Creek Limited Partnership
Sacramento Municipal Utility District

Local Agencies--*Continued*

Sacramento County Regional Sanitation District
San Benito County Water District
San Bernardino County Flood Control District
San Bernardino Valley Municipal Water District
San Diego County Department of Public Works
San Francisco, city and county of, Hetch Hetchy Water and Power
San Francisco Water Department
San Gorgonio Pass Water Agency
San Luis Obispo County Engineering Department
San Mateo County
Santa Barbara, city of
Santa Barbara County Flood Control and Water Conservation District
Santa Barbara County Water Agency
Santa Clara Valley Water District
Santa Cruz, city of
Santa Cruz County Flood Control and Water Conservation District
Santa Margarita River Watershed (watermaster)
Santa Maria Valley Water Conservation District
Santa Ynez River Water Conservation District
Scotts Valley Water District
Sonoma County Planning Department
Sonoma County Water Agency
South Sutter Water District
Southern California Edison Company
STS Hydropower Ltd.
Synergics, Inc.
Tulare County Flood Control District
Tuolumne County
Turlock Irrigation District
United Water Conservation District
University of California, Davis

Local Agencies--*Continued*

Ventura, city of
Ventura County Public Works Agency
Water Replenishment District of Southern California
Woodbridge Irrigation District
Yolo County Flood Control and Water Conservation District
Yuba County Water Agency

Federal Agencies

Department of the Air Force
- Edwards Air Force Base
- March Air Force Base

Department of the Army
- Corps of Engineers
  - Los Angeles District
  - Sacramento District
  - San Francisco District
- Fort Irwin

U.S. Department of the Interior
- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Reclamation
- Fish and Wildlife Service
- National Park Service

U.S. Environmental Protection Agency

Department of the Navy
- U.S. Navy
- Navy Facilities Engineering Command, Southwest, San Diego
- U.S. Marine Corps
- Marine Corps Air Ground Combat Center, Twentynine Palms
- Marine Corps Base, Camp Pendleton
- Marine Corps Logistics Base, Barstow

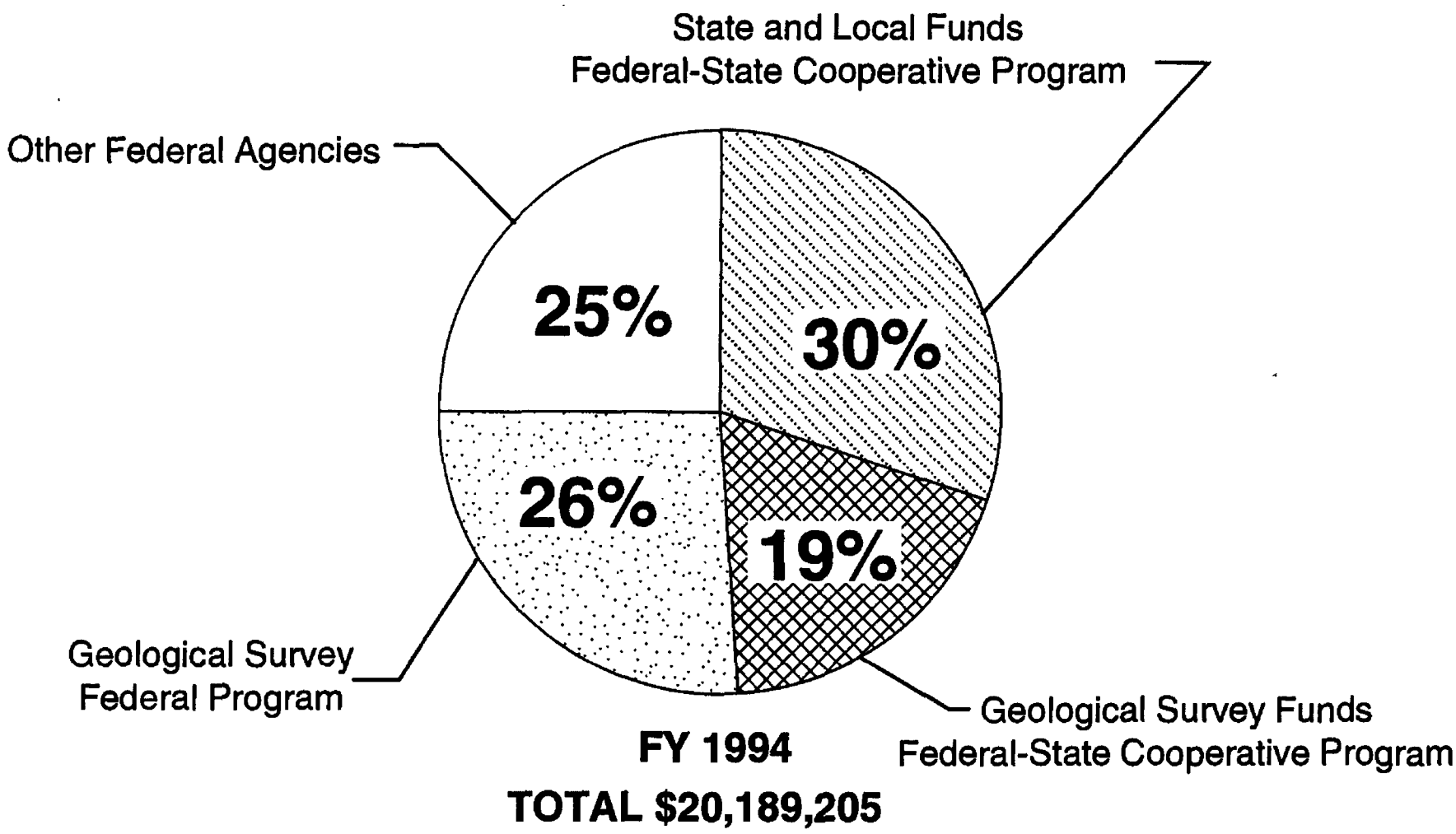

Figure 3. Sources of California District funds in fiscal year 1994.

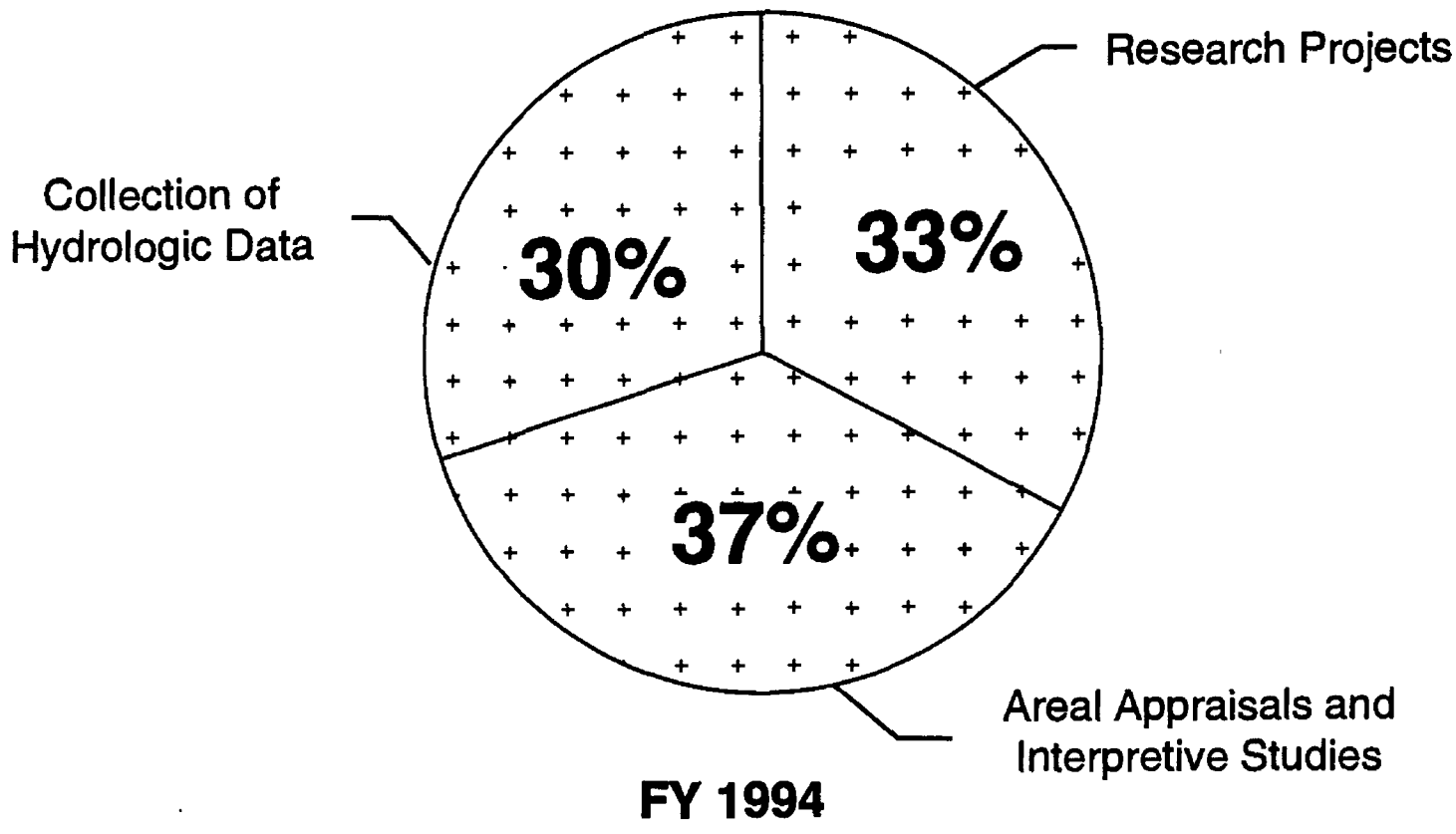

Figure 4. Categories of investigations in the California District, by funding, fiscal year 1994.

WATER CONDITIONS

The 1994 water year (October 1, 1993, to September 30, 1994) brought a return of below-average precipitation and runoff throughout California. Above-average precipitation during 1993 interceded between the precipitation deficient years of 1987-92 and 1994. As a result of the higher 1993 precipitation, an increase in reservoir storage during 1993 provided a much needed boost to the State's water supply during 1994, lessening the adverse effects of another dry year.

Precipitation during the 1994 water year was 66 percent of average statewide with runoff only 40 percent of average (fig. 5). All areas of the State had below-average runoff, with runoff in some areas in the north approaching or exceeding annual deficiencies for each of the years of the 1987-92 drought (fig. 6, station 2). Runoff from the entire Sacramento River basin, which typically provides about one-quarter of the water used by California's farms and cities, also was less than for any year of the recent drought and the fourth lowest on record, following 1977, 1924, and 1931 (fig. 7). Because of the low runoff in the Sacramento River basin, the 1994 water year was classified as critically dry by State and Federal water officials.

At the beginning of the 1994 water year, water storage in the major reservoirs was 106 percent of average for that date (fig. 8); however, by the end of the year, storage had dropped to only 73 percent, still well above the 58 percent at the end of the 1992 water year but just barely exceeding the 70 percent "drought" threshold established by the State. Because of the dry conditions, water deliveries by the State's two largest water projects were significantly reduced. The State Water Project delivered 50 percent of average. The Central Valley Project delivered 35 percent to agricultural contractors and 75 percent to urban and water-rights contractors, wildlife refuges, and environmental restoration projects.

The first 4 months of the 1994 water year (October through January) set the pattern for the year with well below-average precipitation for each of the months. Cumulative precipitation for the 4 months was 55 percent of average. Statewide runoff in October was only 78 percent of average, reflecting the dry month as well as the preceding dry summer and the possible lingering effects of the 1987-92 drought on base flow. The South Coast region, however, continued to show residual effects of 2 consecutive wet years in that region (1992-93) with runoff in October 165 percent of average. However, by the end of January, the South Coast region also had below-average precipitation with runoff for the month only 41 percent of average. Statewide runoff for October to January was only 34 percent of average. At the end of January, reservoir storage had dropped below the average for the date even though reservoir storage had finally begun to increase, in absolute terms, for the first time that year. Normally, reservoir storage begins to increase in November. California's natural water storage--the snowpack--was only 50 percent of average by the end of January.

In February, precipitation was slightly above average, raising the snowpack to 80 percent of average and giving at least the hope that the year would not end with a severe water deficit. However, the wet February was followed by a dry March--one of the driest on record--with precipitation for the month only 39 percent of average and the snowpack only 50 percent of average. April precipitation also was below average. May was a wet month with precipitation two to three times average over most of the State, but it was too little too late. In relative terms, an extremely wet May, which normally accounts for only 4 percent of the year's precipitation, cannot make up for a series of dry winter months. January, for example, normally accounts for 18 percent of the year's precipitation. With the typically wet winter months past, the deficit was too much to make up. Even with above-average precipitation and peak runoff from snowmelt during May, runoff was only 48 percent of average.

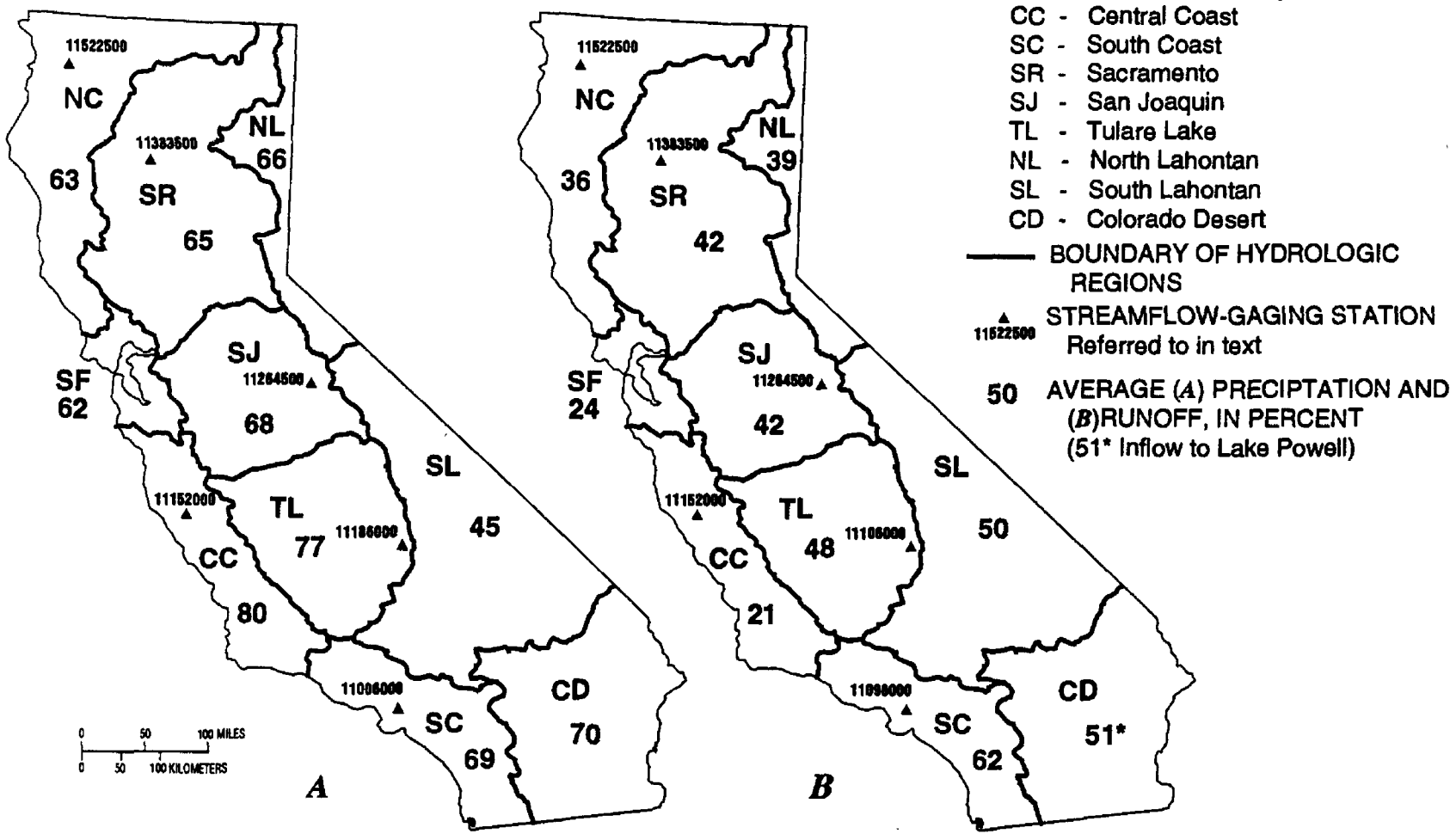

Figure 5. Precipitation and runoff for the 1994 water year, in percent, by hydrologic region relative to long-term average. Statewide precipitation was 67 percent and statewide runoff was 42 percent. (Data compiled by California Department of Water Resources).

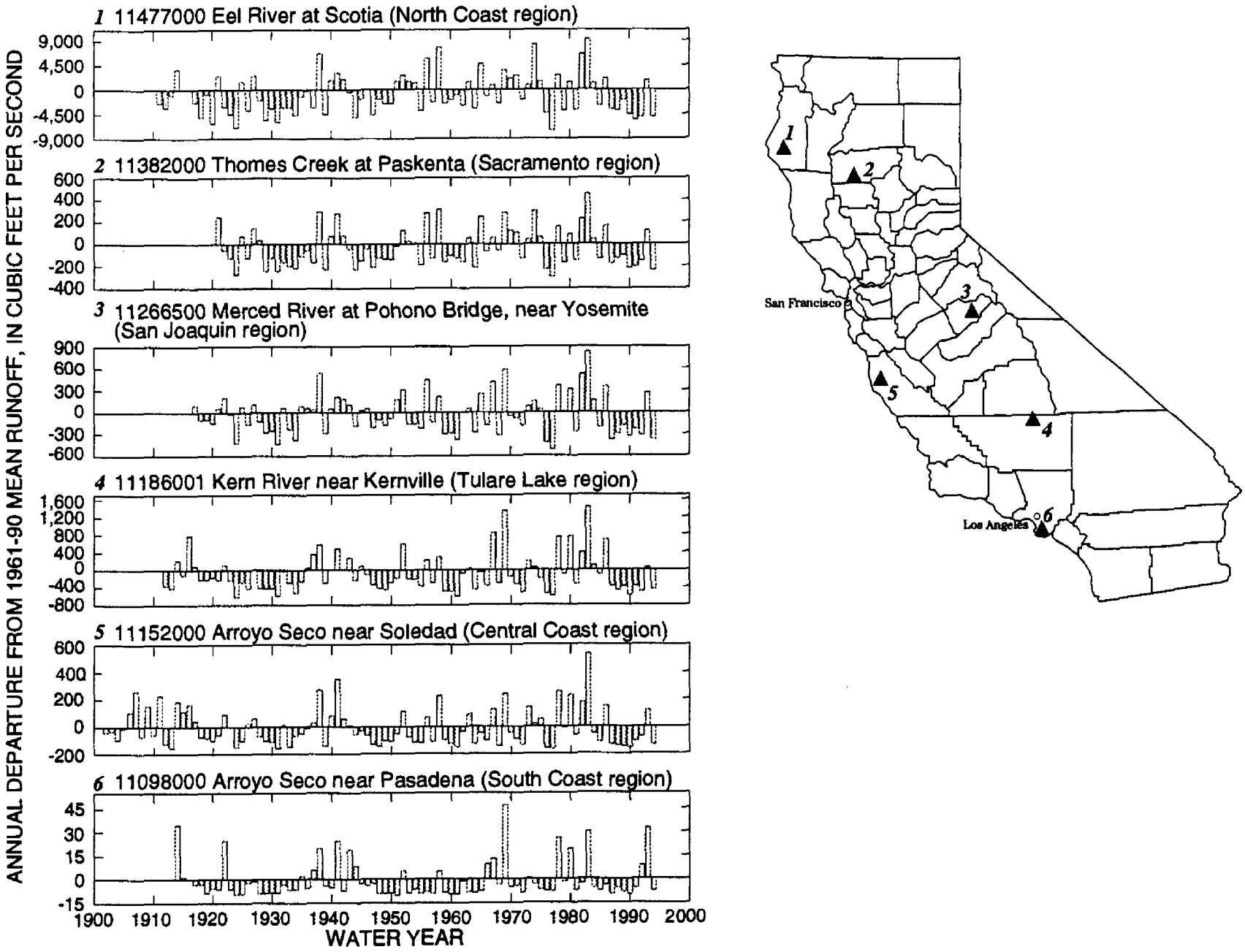

Figure 6. Annual departure from 1961-90 mean runoff at six unregulated streamflow-gaging stations through 1994 water year.

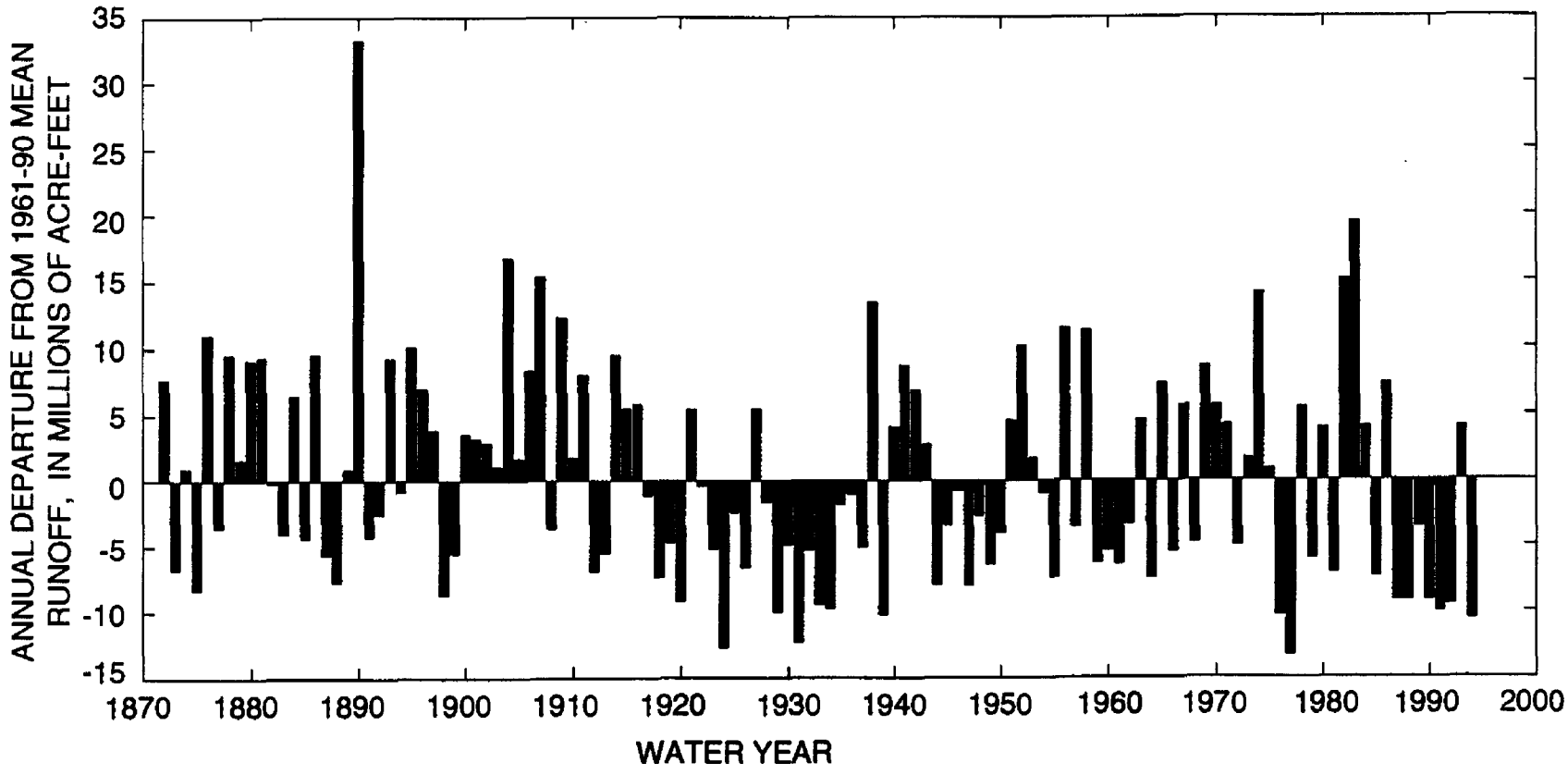

Figure 7. Annual departure from 1961-90 averge runoff in the Sacramento River basin for water years 1872-1994. The Sacramento River basin runoff is the combined flows from the upper Sacramento, Feather, Yuba, and American River basins, adjusted to represent unimpaired runoff. Flows for 1872 to 1905 were estimated from historical data. (Data compiled from the California Department of Water Resources.)

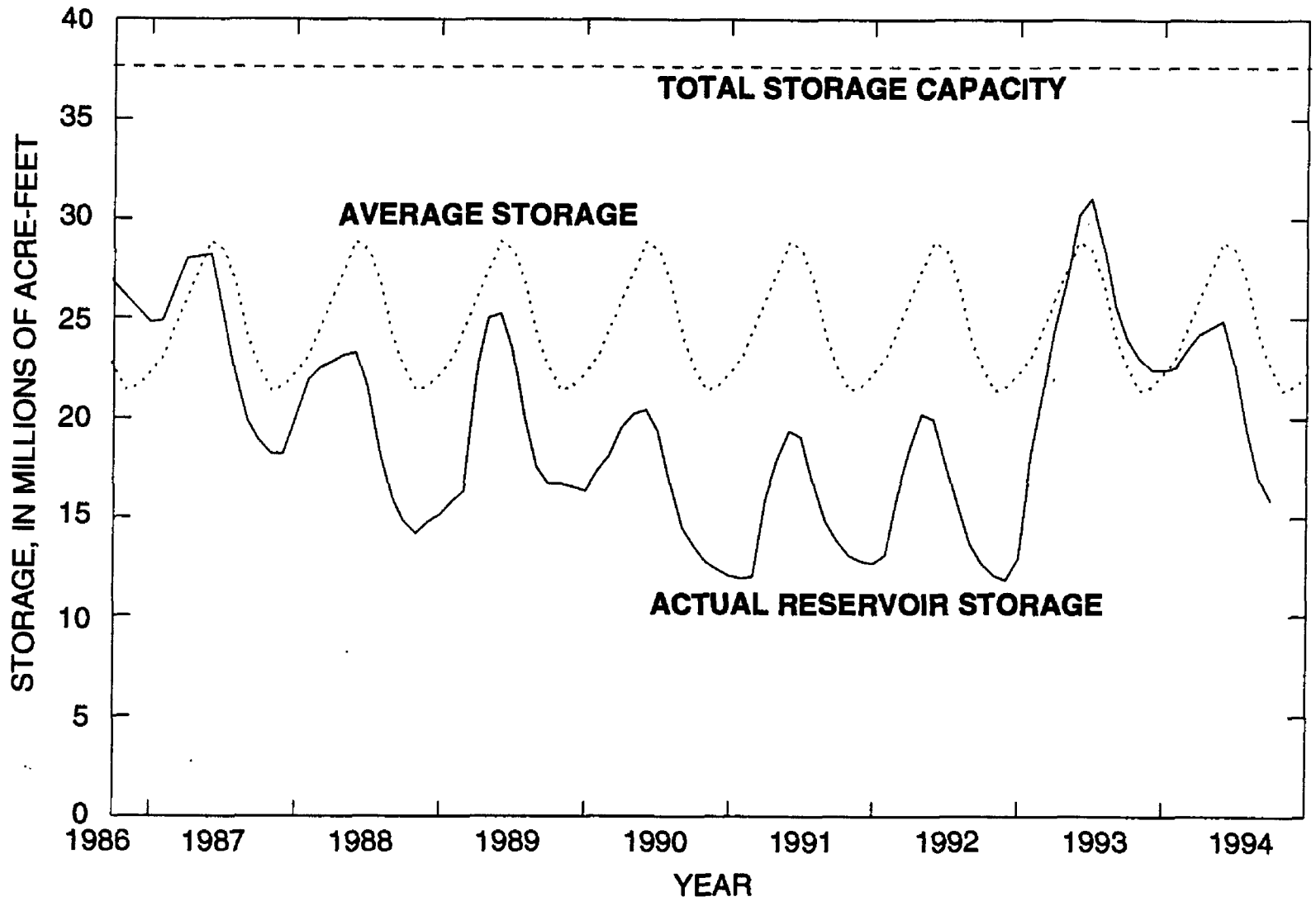

Figure 8. Statewide reservoir storage, 1986-94, for 155 major reservoirs. (Data compiled by California Department of Water Resources.)

The cumulative effects of below-average runoff during 7 of the past 8 years in the Sacramento River basin are shown in figure 9. The wet year in 1993 did much to alleviate the short-term water-supply problems that had plagued the State during the 1987-92 drought, but the cumulative long-term effects of below-average runoff continued to mount during 1994. The deficiencies in runoff for either 1992 or 1994 alone more than canceled the surplus in 1993. The 8-year period between 1987-94 may not be considered a single "drought" because of the wet 1993 water year, but, it is the driest 8-year period in the 123 years of record for the Sacramento River basin, just edging out the overlapping periods 1928-35 and 1929-36. The 1987-94 period produced only 61 percent of average runoff.

An example of the cumulative effects of below-average precipitation and runoff the past 8 years can be seen using the water levels of Lake Tahoe (fig. 10). For a fifth consecutive year, the water year ended with no usable storage because the water level in the lake was below the natural rim. In fact, the water level never reached the rim during the 1994 water year. Historical records of water levels in the lake show that only twice before (1991 and 1992) have water levels stayed below the rim for an entire year.

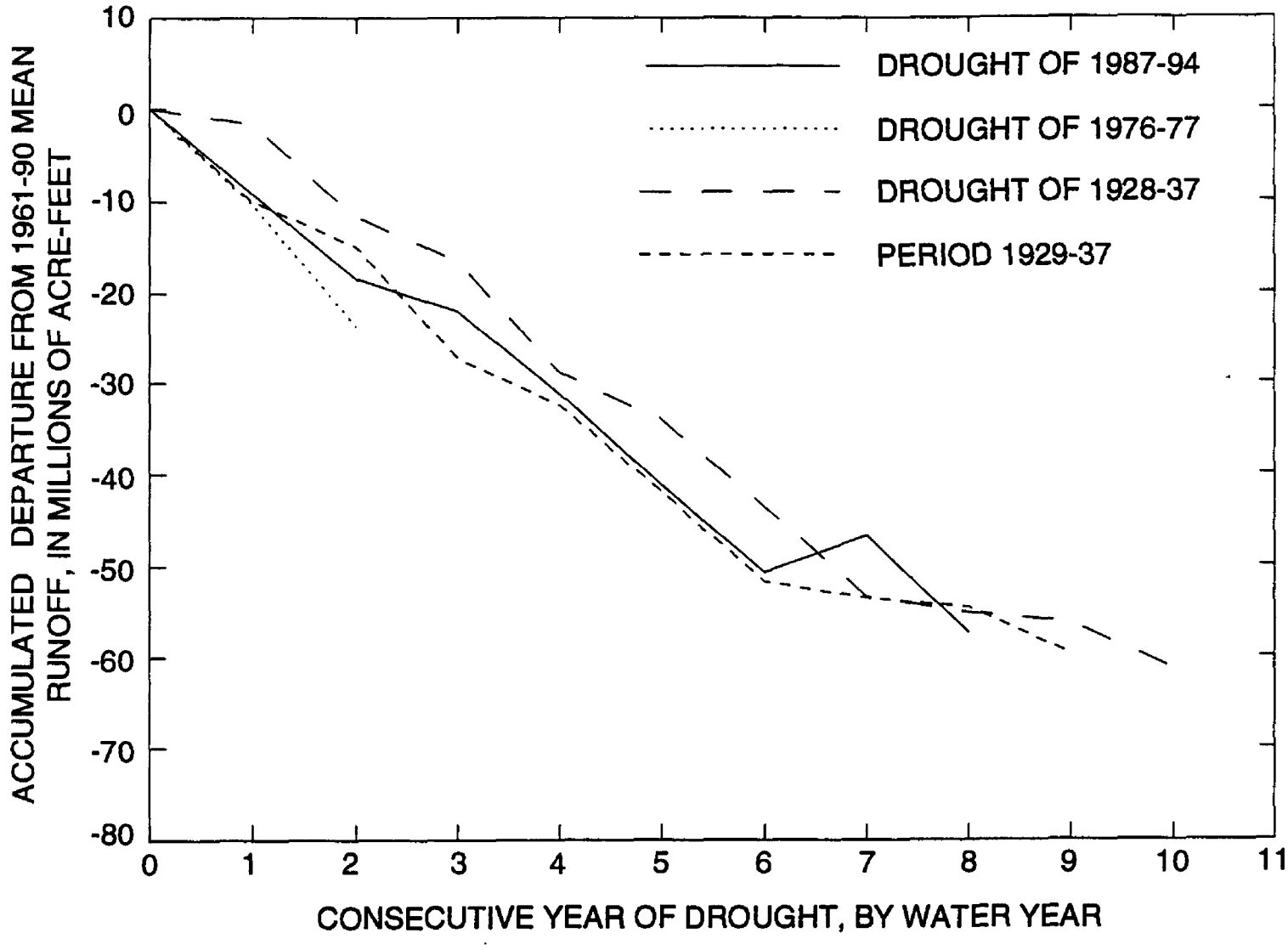

Figure 9. Accumulated departure from 1961-90 mean runoff in the Sacramento River basin for selected drought periods. The period 1929-37, imbedded within the longer 1928-37 drought, is shown for comparison.

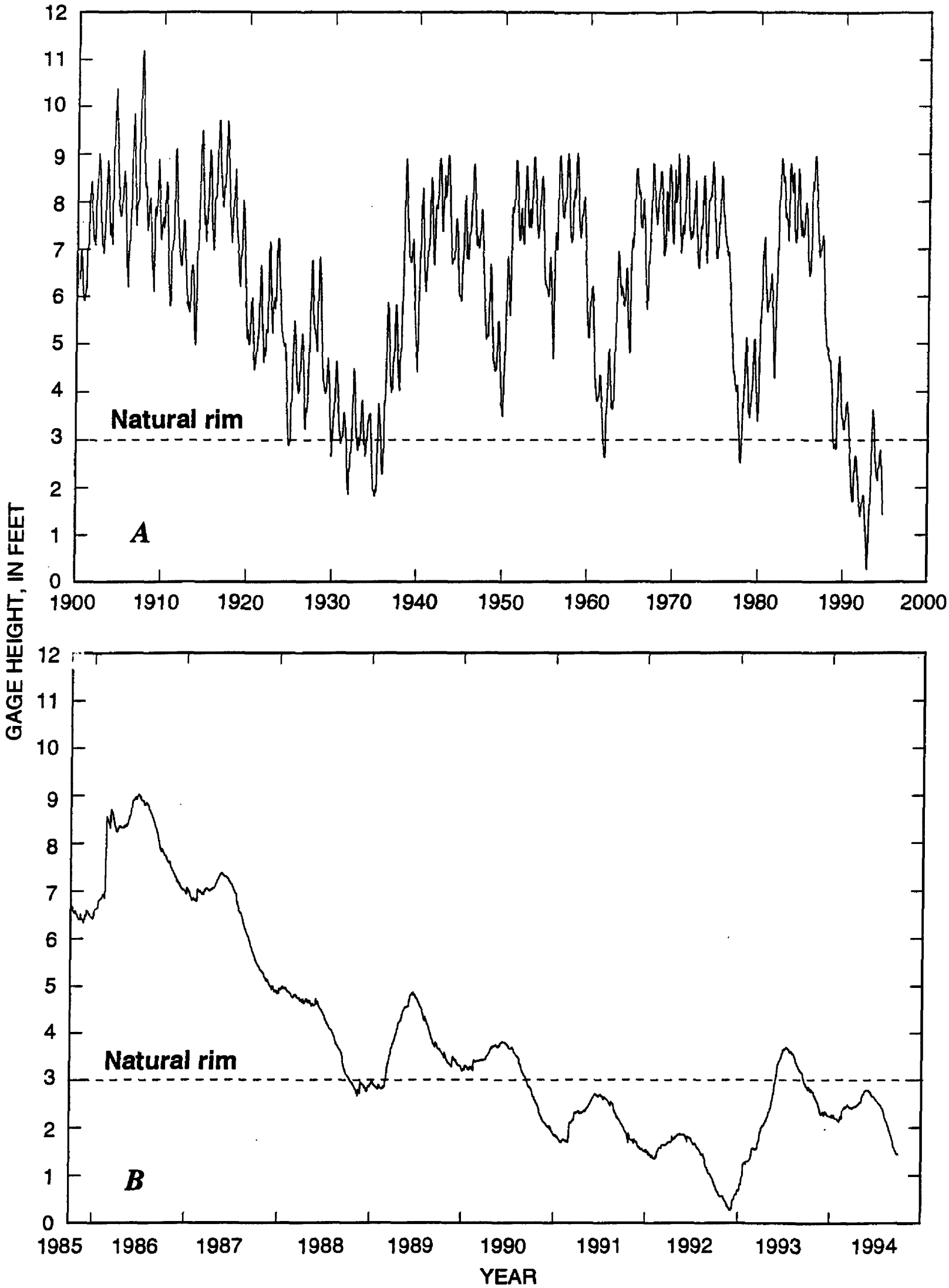

Figure 10. Water levels in Lake Tahoe. The natural rim is the level below which water cannot flow out of the lake. Add 6,220 feet to adjust gage heights to elevations above sea level. ***A,*** Month-end water levels for 1900-94. ***B,*** Daily water levels for October 1985 to September 1994.

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PROJECT DESCRIPTIONS

SURFACE-WATER STATIONS

Number: CA001

Location: Statewide (See accompanying map)

Project Chief: James R. Mullen

Period of Project: Continuing

Problem: Surface-water information is needed for surveillance, planning, design, hazard warning, and operation and management in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. An appropriate data base is necessary to provide this information.

Objectives: Collect timely and high quality surface-water data for (1) assessment of water resources, (2) operation of reservoirs and industries, (3) forecasting flow, (4) disposal of wastes and pollution controls, (5) discharge data to accompany water-quality measurement, (6) compact and legal requirements, and (7) research or special studies. Collect data necessary for analytical studies to define the statistical properties of, and trends in, the occurrence of water in streams, lakes, and estuaries for use in planning and design.

Approach: Standard methods of data collection are used as described in the series "Techniques of Water-Resources Investigations of the U.S. Geological Survey." Partial-record gaging is used instead of continuous-record gaging where it serves the required purpose.

Progress: Surface-water data for 812 continuous-record streamflow stations were collected, reviewed, and compiled for publication. Data were collected or reviewed from 155 reservoir stations. Data were collected and compiled for 100 partial-record stream and reservoir sites that provide peak flow, low flow, seasonal flow, limited range of discharge, or stage information. Installation of additional satellite data-collection platforms and telephone modems for real-time transmission of streamflow information from selected sites continued. Data for 1993 were published in four volumes of the annual data-report series.

Plans for Fiscal Year 1995: Statewide data collection and review and installation of additional satellite data-collection platforms and telephone modems will continue. Streamflow data will be published in the annual data-report series for water year 1994.

Reports:

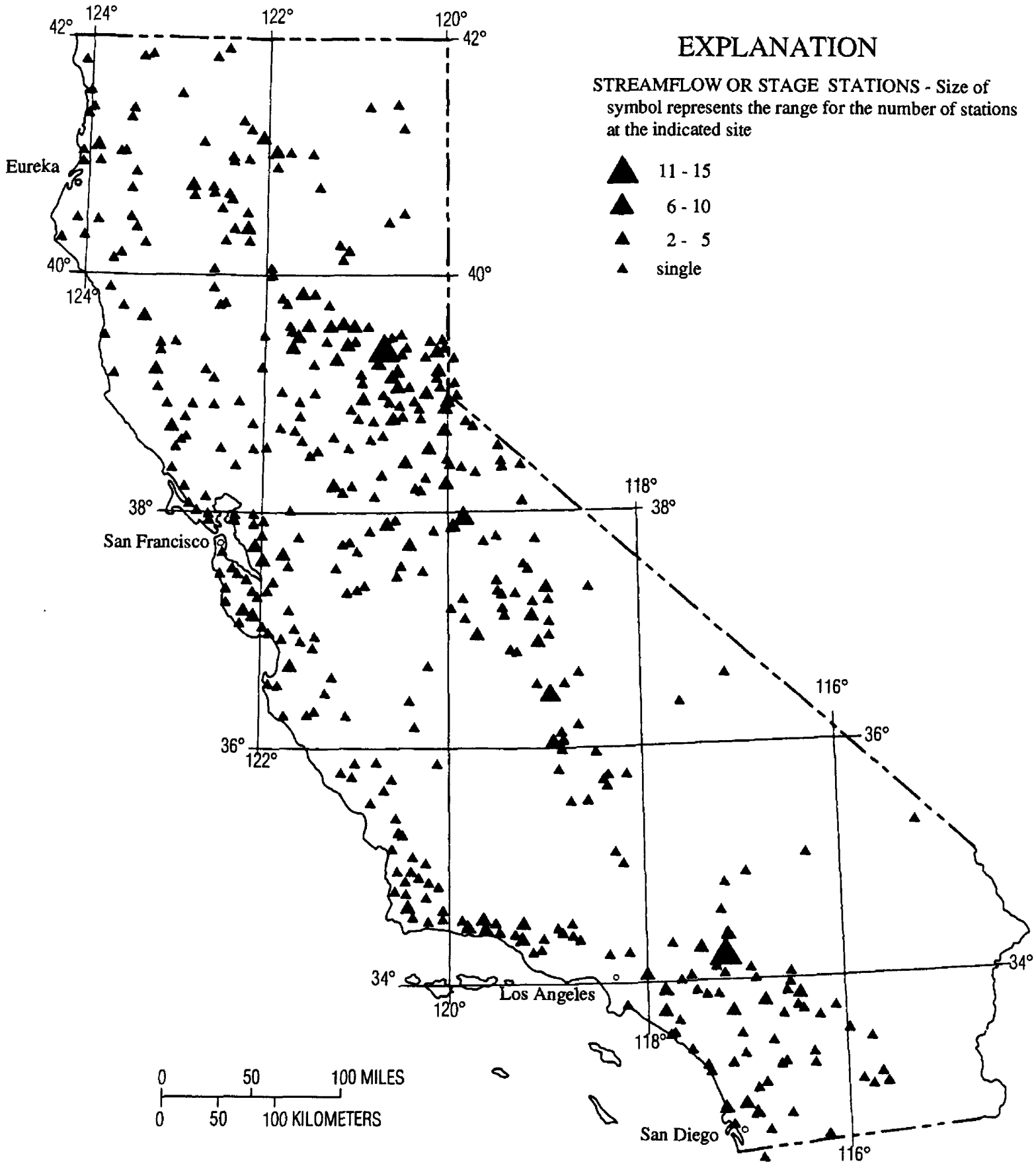
Johnson, J.A., 1994, Water resources data--California, water year 1993. Volume 5. Ground water data: U.S. Geological Survey Water-Data Report CA-93-5, 437 p.

Mullen, J.R., Anderson, S.W., and Hayes, P.D., 1994, Water resources data--California, water year 1993. Volume 3. Southern Central Valley basins and the Great Basin from Walker River to Truckee River: U.S. Geological Survey Water-Data Report CA-93-3, 583 p.

Mullen, J.R., Friebel, M.F., Markham, K.L., and Anderson, S.W., 1994, Water resources data--California, water year 1993. Volume 4. Northern Central Valley basins and the Great Basin from Honey Lake basin to Oregon State line: U.S. Geological Survey Water-Data Report CA-93-4, 437 p.

Mullen, J.R., Hayes, P.D., and Agajanian, J.A., 1994, Water resources data--California, water year 1993. Volume 1. Southern Great Basin from Mexican border to Mono Lake basin, and Pacific slope basins from Tijuana River to Santa Maria River: U.S. Geological Survey Water-Data Report CA-93-1, 440 p.

Palmer, J.R., Friebel, M.F., Trujillo, L.F., and Markham, K.L., 1994, Water resources data--California, water year 1993. Volume 2. Pacific slope basins from Arroyo Grande to Oregon State line except Central Valley: U.S. Geological Survey Water-Data Report CA-93-2, 391 p.



Location of streamflow-measuring stations.

GROUND-WATER STATIONS

Number: CA002

Location: Statewide (See accompanying map)

Project Chief: Charles E. Lamb

Period of Project: Continuing

Problem: Ground water accounts for 39 percent of freshwater withdrawals in California--more than 14 billion gallons per day. More than 10 million people are served by ground-water supplies. In addition, 12.5 billion gallons per day are withdrawn for irrigation. The distribution and quality of ground water is highly variable related to geology, natural, and manmade stresses. Monitoring of ground-water levels and chemistry is essential to the management and development of the resource.

Objectives: Collect ground-water-level and ground-water-quality data to assess the quantity, quality, and distribution of ground water. These data serve as management tools for national and local water planning.

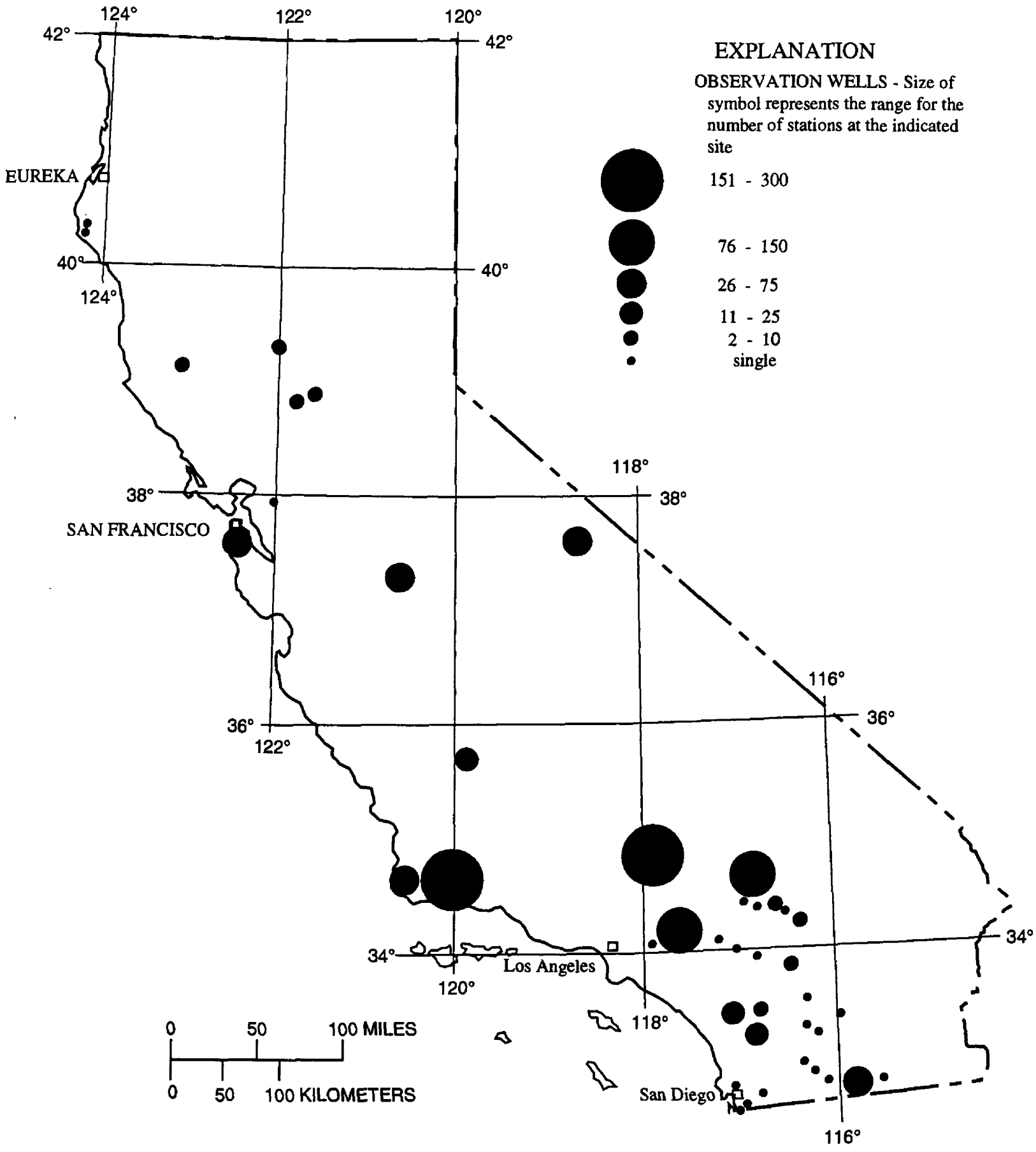
Approach: Water levels are measured and recorded with varying frequencies: continuously, monthly, semiannually, and annually. Water samples are collected for field and laboratory analysis. Standard methods of data collection are used as described in the "National Handbook of Recommended Methods for Water-Data Acquisition" and other Water Resources Department memorandums.

Progress: Collection and compilation of ground-water-level data continued at 926 long-term sites, 82 short-term sites, and 41 continuous-recorder wells. Samples were collected and analyzed for chemical quality at 272 long-term sites and 45 short-term sites. A data index for water year 1993 will be published in an annual fact sheet.

Plans for Fiscal Year 1995: Statewide data collection and record processing of ground-water levels and quality will continue. A ground-water-data index will be published in an annual fact sheet.

Reports:

Johnson, J.A., 1994, Water resources data--California, water year 1993. Volume 5. Ground water data: U.S. Geological Survey Water-Data Report CA-93-5, 437 p.



Location of selected observation wells.

WATER-QUALITY STATIONS

Number: CA003

Location: Statewide (See accompanying map)

Project Chief: Rick T. Iwatsubo

Period of Project: Continuing

Problem: Water-resource planning and water-quality assessment require a nationwide base level of relatively standardized information. For informed planning and realistic assessment of water resources, the chemical and physical quality of rivers and streams must be defined and monitored.

Objectives: Provide a national bank of water-quality data for broad Federal planning and action programs and provide data for Federal management of interstate and international waters.

Approach: A network of water-quality stations are operated to provide averages for chemical concentrations, loads, and time trends as required by planning and management agencies.

Progress: Water-quality data were collected periodically at many sites throughout California. Water-quality samples were collected bimonthly at 7 NASQAN (National Stream Quality Accounting Network) stations and quarterly at 3 NASQAN stations and 3 Hydrologic Benchmark stations. Water temperature or specific conductance were measured continuously at 51 sites. Precipitation samples were collected weekly at the National Trends Network stations in the Los Padres National Forest and at Yreka. Water-quality data also were collected at 48 stream or reservoir sites. Water samples were analyzed from 317 observation wells. Data for 1993 were published in the annual data report series.

Plans for Fiscal Year 1995: Statewide data collection and the processing of surface-water, ground-water, and precipitation samples will continue. All data will be published in the annual data report series.

Reports:

Johnson, J.A., 1994, Water resources data--California, water year 1993. Volume 5. Ground water data: U.S. Geological Survey Water-Data Report CA-93-5, 437 p.

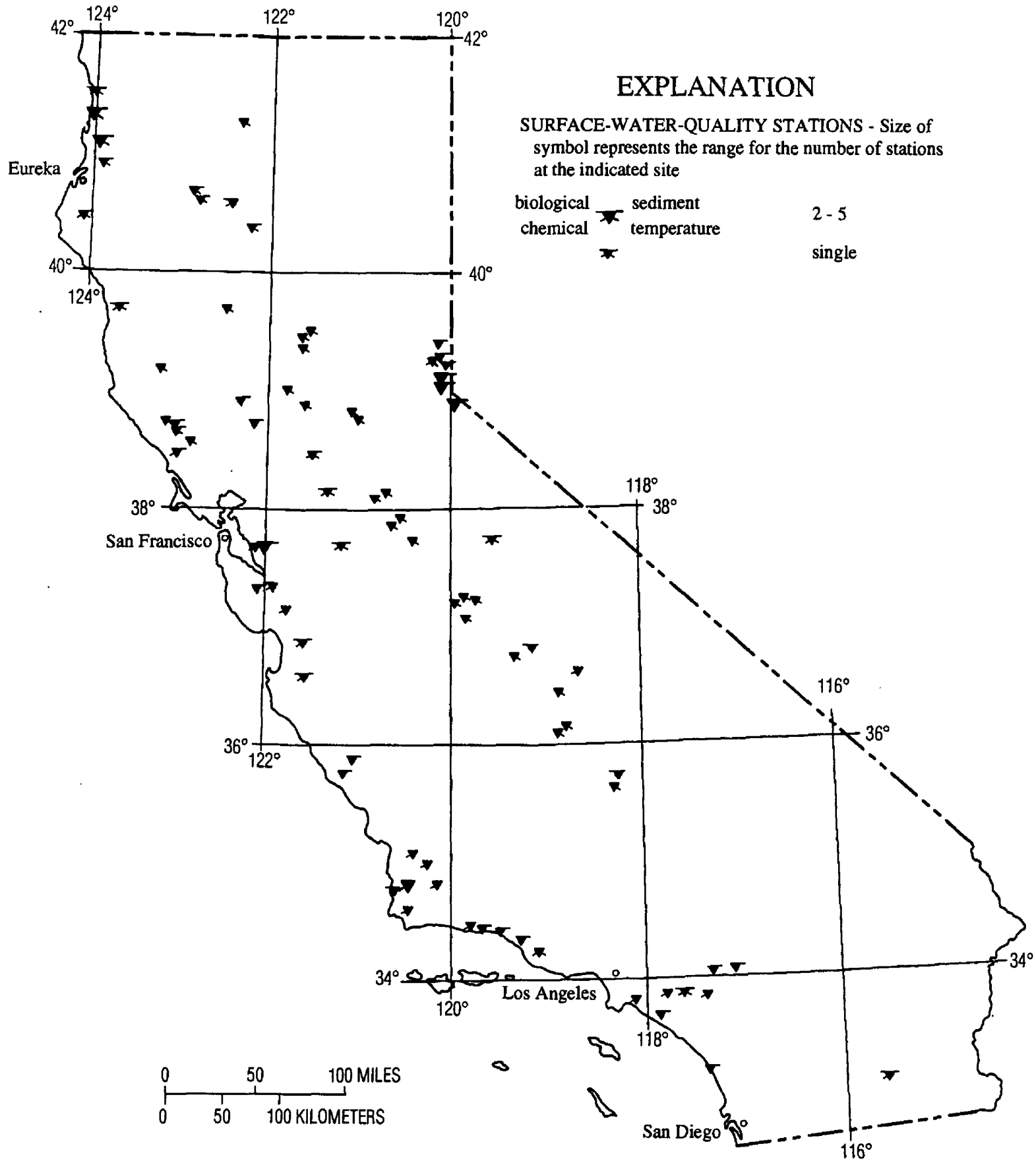
Mullen, J.R., Anderson, S.W., and Hayes, P.D., 1994, Water resources data--California, water year 1993. Volume 3. Southern Central Valley basins and the Great Basin from Walker River to Truckee River: U.S. Geological Survey Water-Data Report CA-93-3, 583 p.

Mullen, J.R., Friebel, M.F., Markham, K.L., and Anderson, S.W., 1994, Water resources data--California, water year 1993. Volume 4. Northern Central Valley basins and the Great Basin from Honey Lake basin to Oregon State line: U.S. Geological Survey Water-Data Report CA-93-4, 437 p.

Mullen, J.R., Hayes, P.D., and Agajanian, J.A., 1994, Water resources data--California, water year 1993. Volume 1. Southern Great Basin from Mexican border to Mono Lake basin, and Pacific slope basins from Tijuana River to Santa Maria River: U.S. Geological Survey Water-Data Report CA-93-1, 440 p.

Palmer, J.R., Friebel, M.F., Trujillo, L.F., and Markham, K.L., 1994, Water resources data--California, water year 1993. Volume 2. Pacific slope basins from Arroyo Grande to Oregon State line except Central Valley: U.S. Geological Survey Water-Data Report CA-93-2, 391 p.

Schroeder, R.A., 1994, Point-source identification from PCB analyses of surficial sediment in San Diego Bay, Califoria (abs.): Eos, Transactions of the American Geophysical Union, v. 75, no. 3, Supplement, p. 175.



Location of surface-water-quality monitoring stations.

SEDIMENT STATIONS

Number: CA004

Location: Statewide (See accompanying map for water-quality stations, page 23)

Project Chief: Lawrence A. Freeman

Period of Project: Continuing

Problem: The environmental effects of erosion, movement, and deposition of sediment can be devastating. Knowledge of sediment transport is essential in the development and management of water and land resources. The wide variation in drainage basin and precipitation characteristics in California results in significant differences in the quantity and quality of fluvial sediment; this variability requires that sediment be monitored frequently at several locations within the State for effective assessment of sediment transport.

Objectives: Provide sediment data that can be used to (1) develop land-management practices that will reduce erosion rates, (2) evaluate the effects of timber harvesting on fisheries, (3) determine the effects of debris basins and drop structures on sediment transport, (4) monitor reservoir capacity losses for flood control and water supply, (5) determine the relation of sediment to algae growth in lakes, (6) evaluate changes in coastal morphology caused by coastal river sediment, (7) determine the effects of urbanization on channel morphology, and (8) estimate channel change that would result from proposed dam sites.

Approach: Suspended-sediment and bed-material samples are collected at specific streams within the State. Bed-load samples also are collected at those sites that are total-load stations if stream characteristics are suitable. Daily concentration and suspended-sediment discharge will be computed for all daily sediment stations. Monthly bed-load discharge are estimated for all daily total-load stations. Selected suspended-sediment, bed-load, and bed-material samples are analyzed for particle-size distribution.

Progress: Sediment data were collected at 14 daily, 20 periodic, 10 NASQAN (National Stream Quality Accounting Network), and 3 Hydrologic Benchmark stations. Data for water 1993 were published in four volumes of the annual data report series.

Plans for Fiscal Year 1995: Statewide data collection and processing of sediment samples will continue. All data will be published in the annual data report series.

Reports:

Fujimura, R.J., Huang, C., Finalayson, B.J., and Alpers, C.N., 1994, Toxicity and metal content of reservoir sediments associated with an abandoned copper-zinc mine (abs.): American Chemical Society, Division of Environmental Chemistry, San Diego, California, March 13-18, 1994.

Mullen, J.R., Anderson, S.W., and Hayes, P.D., 1994, Water resources data--California, water year 1993. Volume 3. Southern Central Valley basins and the Great Basin from Walker River to Truckee River: U.S. Geological Survey Water-Data Report CA-93-3, 583 p.

Mullen, J.R., Friebel, M.F., Markham, K.L., and Anderson, S.W., 1994, Water resources data--California, water year 1993. Volume 4. Northern Central Valley basins and the Great Basin from Honey Lake basin to Oregon State line: U.S. Geological Survey Water-Data Report CA-93-4, 437 p.

Mullen, J.R., Hayes, P.D., and Agajanian, J.A., 1994, Water resources data--California, water year 1993. Volume 1. Southern Great Basin from Mexican border to Mono Lake basin, and Pacific slope basins from Tijuana River to Santa Maria River: U.S. Geological Survey Water-Data Report CA-93-1, 440 p.

Palmer, J.R., Friebel, M.F., Trujillo, L.F., and Markham, K.L., 1994, Water resources data--California, water year 1993. Volume 2. Pacific slope basins from Arroyo Grande to Oregon State line except Central Valley: U.S. Geological Survey Water-Data Report CA-93-2, 391 p.

NATIONAL TRENDS NETWORK FOR MONITORING ATMOSPHERIC DEPOSITION

Number: CA005

Location: Statewide (See accompanying map)

Project Chief: James R. Mullen

Period of Project: Continuing

Problem: Some lakes in the United States are becoming more acidic causing fish populations to decrease.

Objectives: To determine the areal and temporal variation of wet-atmospheric deposition in the United States. Sites in California are part of a national program.

Approach: Wet-atmospheric deposition is sampled and analyzed and annual loading is determined for parts of California. Atmospheric-deposition samplers are operated at Chuchupate ranger station in Los Padres National Forest, Ventura County, California, and at a station near Yreka, Siskiyou County. Other sampling sites may be added as needed.

Progress: Precipitation data were collected at Chuchupate ranger station in Los Padres National Forest, Ventura County, with assistance from the U.S. Forest Service. Operations at the precipitation stations near Yreka, Siskiyou County, were reviewed. No sampling sites were added during fiscal year 1994.

Plans for Fiscal Year 1995: Collection and analysis of atmospheric-deposition samples will continue at Chuchupate ranger station. Annual inspections of the Yreka site will continue.

Reports: None

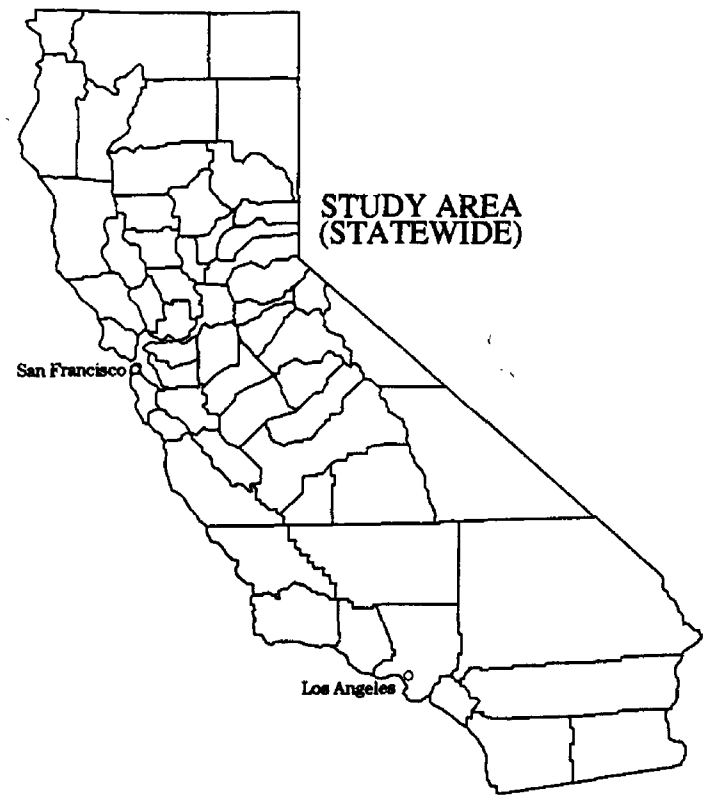
WATER-USE INFORMATION FOR CALIFORNIA

Number: CA007

Cooperating Agency: California Department of Water Resources

Project Chief: William E. Templin

Period of Project: Continuing



Problem: Water-use estimates are needed to effectively manage the water resources of the Nation. Water resources are managed at three levels: national, state, and local (county drainage basins and aquifers). Water-use estimates must be consistently updated and reevaluated to assure the validity of the comparisons and conclusions of the estimates. California continually has the largest water-use volume of any state in the Nation; its multiagency water-management organizational structure and the magnitude of its water users create a complex water-use information environment. The challenge is to meet current and future water-use information needs within the limits of available water resources.

Objectives: (1) Determine how much fresh and saline surface and ground water is withdrawn and for what purposes, how much of this water is consumed during use, and how much water is returned to surface and underground sources after use; (2) maintain and improve computerized systems to store and retrieve statewide and site-specific water-use information; (3) identify and evaluate methods commonly used to collect, analyze, and disseminate water-use information and then devise and apply new methods and techniques as necessary to improve these methods; and (4) make available the values and applications of water-use information.

Approach: For fiscal 1994, focus will be on water use in the Sacramento-San Joaquin Delta. All existing information and data collection activities will be coordinated to develop the best available set of water-use data for this area. Methods to improve the quantification of water diversions from and returns to the delta channels will be researched. Water-use information will continue to be coordinated with the work of other Federal, State, and local agencies through close involvement with the California Water-Use Coordination Committee and its subcommittees.

Progress: Water-use reports were published for Antelope Valley and the western San Joaquin Valley. Contributions were made to a journal article on applications of forecasting model systems and to a report on water use in the south San Francisco Bay area. Significant findings or results of water-use studies during fiscal year 1994 include the following: (1) reported annual urban water uses in the Antelope Valley have exceeded reported annual agricultural uses since 1986. This is a shift in water use for this historically rural valley; (2) estimates of irrigation water supply and demand were released for 32 water districts in the western San Joaquin Valley. These estimates were released in computer-readable (ASCII) format on diskettes that contain data on surface-water deliveries, irrigated crop acreage, estimated crop-water requirements, and calculated crop-water demand for each section of land. Prior to this release, data for this area had not been available at this level of detail; (3) estimates of irrigation-drainage discharge made from power-consumption and pump-capacity data on Twitchell Island in the Sacramento-San Joaquin Delta are in agreement with metered discharge data.

Plans for Fiscal Year 1995: For fiscal year 1995, the focus will be on estimating drainage discharges in the Sacramento-San Joaquin Delta using power-consumption methods. Work also will include preparing for the update of statewide water-use data bases for the 1995 calendar year by reviewing previously used methods. A plan will be developed to improve the accuracy of information and to revise methods used so that they are less time-intensive. The final report on the water-resources data network for the northern and coastal areas of Monterey County will be submitted to the Director for approval; following approval the report will be prepared for publication. Work will continue on quantifying irrigation drainage discharges and siphon withdrawals in the delta. Priorities for program development will focus, first, on statewide data-base development and enhancement and, second, on localized area studies.

Reports:

Templin, W.E., and Haltom, T.C., 1994, Irrigation water supply and demand data for 1976, 1980, and 1984 for the western San Joaquin Valley, California: U.S. Geological Survey Open-File Report 94-335, 8 p. and 1 diskette.

FLOOD HYDROLOGY OF BUTTE BASIN, SACRAMENTO VALLEY

Number: CA271

Cooperating Agency: California Department of Water Resources

Project Chief: Jerry G. Harmon

Period of Project: Continuing

Problem: Flooding in the Sacramento River basin may cause changes in the magnitude and duration of overbank flows to Butte basin and increased amounts of lateral erosion. Continued lateral migration of the channel may cause the Sacramento River to change course and enter Butte basin or allow excessive flows down the main channel of the river where the design channel capacity decreases in leveed reaches.

Objectives: (1) Define relations and document changes in the proportional division of floodflows between the Sacramento River and Butte basin; (2) show the results of channel scour, channel fill, and streambank erosion at selected cross sections of the river; and (3) present water-surface profiles of floods to provide a base for documenting changes in channel-flow characteristics.

Approach: Flood data (part of the ongoing data-collection program) are collected. Channel cross-section data at monumented (selected sites marked by stakes on the riverbanks) sites are collected annually. Flood data include streamflow and surveyed or recorded stage measurements. These data are used to determine if additional construction of levees or weirs are necessary to prevent excessive flows in the river channel.

Progress: Annual cross-section surveys and streamflow-recording gage and crest-stage gage operations continued. Elevations and descriptions of reference marks were documented for surveys of high-water marks along the Sacramento River and in Butte basin, including the Goose Lake flood-relief structure. The open-file report was sent to the printer, and a water-resources investigations report is being prepared for submittal to the Director for approval for publication.

Plans for Fiscal Year 1995: Streamflow-recording gages and crest-stage gages will be in operation during the 1995 flood season. The data-collection network will include peak-stage data near the Goose Lake flood-relief structure, which was constructed in 1988. Elevations and descriptions of reference marks will be documented to relate to floodflow measurements and surveys of high-water marks along the Sacramento River and in Butte basin. Flows will be measured and recorded to document changes or stability in the characteristics of floodflows. Cross sections of the river will be resurveyed annually and compared with data from previous surveys for each of the seven sites. A report describing the channel morphology in a reach of the Sacramento River from 1970-94 will be written.

Reports: None

ESTIMATING TIDAL AND RESIDUAL CIRCULATION IN SAN FRANCISCO BAY AND THE SACRAMENTO-SAN JOAQUIN DELTA

Number: CA419

Cooperating Agency: California Department of Water Resources; California State Water Resources Control Board; U.S. Army Corps of Engineers; and Contra Costa Water District

Project Chief: Lawrence H. Smith

Period of Project: Continuing

Problem: California State and Federal water projects regulate the quantity of fresh water flowing into San Francisco Bay from the Sacramento-San Joaquin River Delta. This regulation has caused a decrease in the annual inflow of fresh water to the bay and has altered the time sequences of inflows during the year. The effect of decreased inflow may be altering the mixing characteristics of the bay and adversely affecting fish and invertebrate populations.

Objectives: To determine the magnitude and location of variations in hydrodynamics (water currents and salinity) within San Francisco Bay that result from changes in fresh-water inflows from the Sacramento-San Joaquin River Delta. To measure tidal flows in the delta and to distinguish between natural variations of flow and variations of flow caused by State and Federal water projects.

Approach: Two- and three-dimensional mathematical models are used to project the effect of variations in delta flows on water currents and salinity in the bay. Currents and salinity are measured during a wide range of delta-flow conditions. A new prototype of a ship-mounted acoustic Doppler current profiling system will be tested and used to measure vertical profiles of currents. A high-resolution, in situ, conductivity-temperature-depth system will be used to measure vertical salinity profiles. Field data will be used as appropriate to calibrate and validate mathematical models. Ultrasonic velocity meters (UVMs) will be used to continuously measure flows in delta channels.

Progress: Calibrations of three UVMs for the Sacramento-San Joaquin Delta were completed, and after considerable troubleshooting of a fourth UVM with a 1,500-foot path length, a preliminary calibration was done. Analysis of data from two of the new UVMs showed the dynamics of delta transfer from the Sacramento River into the central delta. Tidal flows in the transfer channels peak near low slack tide at the time when the incoming tide from downstream begins opposing river flow. Closure of gates on the main transfer channel increases net flows downstream but decreases net flows upstream of the transfer point. To compensate, net seaward flow increases along a different flow path to the bay.

A voluminous, hydrographic data set was collected in Suisun Bay during the spring as part of an interdisciplinary, interagency study. Preliminary analyses of the hydrographic data suggest that a shallow area of the channel in western Suisun Bay provides a topographic block to gravitational circulation and that gravitational circulation farther landward in the main channel is not as important in controlling salt transport as previously was thought. As a result, the nontidal current null zone apparently is detached from the low-salinity part of the bay.

Coding of a new three-dimensional model for all San Francisco Bay continued. A final algorithm was tested and judged satisfactory for hypothetical problems. Most of a major report documenting the model was written. A report on a field data set for testing three-dimensional models was published.

A major summary report on activities during the first 9 years of the project was written, received colleague review, and was submitted for USGS approval.

Plans for Fiscal Year 1995: Three additional UVMs will be installed in the delta and will be calibrated using a broad-band ADCP (acoustic Doppler current profiler) and ADDMS (the Survey's vessel-mounted acoustic Doppler discharge measurement system). Estimates of net delta discharge to San Francisco Bay and of the management index, QWEST, will be computed using these flow measurements.

An additional data set will be collected in Suisun Bay to quantify the horizontal variability of tidal circulation in Suisun Bay and its importance to the transport of salt and sediment.

A three-dimensional model of San Francisco Bay will be implemented and calibration tests will begin using the projects's extensive hydrographic data base.

Project members will help host a workshop sponsored by the USGS San Francisco Bay/Delta Ecosystems Initiative for interested agencies and individuals. This workshop will highlight USGS accomplishments relevant to the issues of the bay and delta.

Reports: None

SOUTHERN CALIFORNIA REGIONAL AQUIFER-SYSTEM ANALYSIS

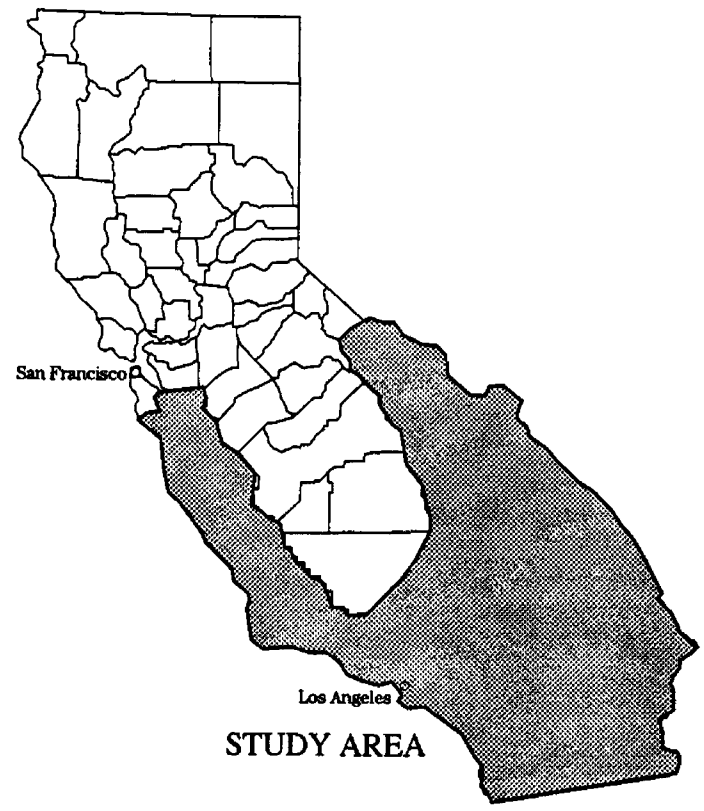
Number: CA424

Cooperating Agency: None. (U.S. Geological Survey Federal Program)

Project Chief: Peter Martin

Period of Project: October 1990 to September 1994 (reactivated)

Problem: To meet the needs for hydrologic information on a regional scale and to develop predictive capabilities to effectively manage the Nation's ground-water resources, the U.S. Geological Survey has initiated a series of hydrologic investigations in the Regional Aquifer Systems Analysis (RASA) program. The RASA study of the southern California basins covers a 75,000-square-mile area. The area includes 89 drainage basins that can be grouped into coastal and desert basins according to common characteristics and relations.



STUDY AREA

Objectives: To analyze major problems and issues affecting ground-water use in southern California including (1) ground-water overdraft, (2) ground-water contamination, (3) seawater intrusion, (4) quantity and distribution of recharge, (5) inter-aquifer flow, and (6) conjunctive use of ground and surface water. Because of the large size of the study area and the number of basins involved, it is impractical to study these problems and issues for each basin. Thus, at least one coastal basin and one desert basin will be selected for intensive study to determine the major geohydrologic processes and human activities that control or influence these problems.

Approach: The coastal basin selected for this intensive study is the Santa Clara-Calleguas basin; the desert basin selected is the Mojave basin. The study will involve assembling available geohydrologic data into the Geographic Information System (GIS), defining the regional geohydrology and geochemistry, and developing ground-water flow and solute-transport models to help understand the ground-water-flow system. Information obtained from these intensive studies will aid in the effective management of the ground-water resources of these and other basins in southern California.

Progress: Santa Clara-Calleguas basin: Most of the efforts in the Santa Clara-Calleguas basin study involved calibrating the ground-water-flow model. Long-term hydrographs of more than 100 wells were compiled and used to calibrate the model. The model was calibrated to simulate steady-state conditions within the basin prior to the 1900's and transient conditions from 1900 through 1993. The transient period was divided into quarterly timesteps. All recharge and discharge data sets were generated and imported into the model using ARC/INFO. Long-term average recharge rates generated for the model are less than the recharge rates estimated by previous investigators.

Mojave River basin: Seven multiple-well monitoring sites were constructed in the basin to define aquifer or depth-dependent ground-water-flow and water-quality characteristics. A paper describing the source and age of ground water in the upper Mojave basin was submitted for review. A major finding presented in this paper is that ground water is extremely old in the Mojave basin, except adjacent to the Mojave River. The stable isotope values of the old water are significantly lighter than present day recharge sources indicating that climatic conditions probably were cooler when the water was recharged. Water-quality data collected in the Barstow area were summarized in a conference proceedings paper. The major finding presented in this paper is that the disposal of sewage effluent is a major source of water-quality degradation in the Barstow area.

Work continued on the development and calibration of a ground-water-flow model for the Mojave River basin. Available isotope data indicate that water in the regional ground-water system is extremely old and that recent recharge to the regional aquifer is minimal. Therefore, a different approach for simulating predevelopment water levels was tested. This approach was based on the premise that during the late Pleistocene the climate was cooler and wetter and greater recharge occurred to the regional aquifer, but since that time, the climate has been warmer and dryer with little or no recharge to the regional aquifer. Water levels for the late Pleistocene were simulated using a steady-state computer-simulation model that was run by applying precipitation recharge over the entire basin. A 10,000-year transient-state simulation then was made with no recharge. During this simulation, ground water drained to the Mojave River and water levels declined. The resulting heads closely matched available predevelopment water-level measurements, indicating that the premise of no recent recharge is tenable.

Plans for Fiscal Year 1995: The professional paper describing the major problems and issues affecting ground-water use in a coastal southern California basin will be completed. The transient-state model for the Mojave River basin also will be completed, and work will begin on writing of a summary report for the Mojave basin.

Reports:

Densmore, J.N., Predmore, S.K., and Martin, Peter, 1994, Use of dissolved-solids and nitrogen concentrations, and deuterium and oxygen isotopes to determine extent and sources of ground-water degradation near Barstow, California, in Proceedings on the Effects of human-induced changes on hydrologic systems, AWRA 1994 Annual Summer Symposium of the American Water Resources Association, Jackson Hole, Wyoming, June 26-29, 1994: American Water Resources Association Technical Publication Series TPS-94-3, p. 871-876.

Gleason, J.D., Veronda, Guida, Smith, G.I., Friedman, Irving, and Martin, Peter, 1994, Deuterium content of water from wells and perennial springs, southeastern California: U.S. Geological Survey Hydrologic Investigations Atlas HA-727, scale 1:100,000, 1 sheet.

HYDROLOGIC STUDIES RELATED TO VOLCANIC ACTIVITY IN LONG VALLEY CALDERA

Number: CA431

Cooperating Agency: U.S. Geological Survey Federal Program; and Mono County

Project Chief: Christopher D. Farrar

Period of Project: Continuing

Problem: Long Valley caldera is a large volcanic depression along the eastern Sierra Nevada Frontal fault system. Since 1978, earthquake activity has increased in the caldera. This earthquake activity, as well as a total uplift of 0.6 meter, probably is a result of rising magma. On May 26, 1982, the U.S. Geological Survey issued a notice of potential volcanic hazard in the Long Valley area. Since then, the Survey has taken the lead in studies that include monitoring, assessment of potential hazards, and research for methods of prediction.

Objectives: Monitor ground water and surface water to detect changes in the hydrologic system caused by geologic processes and phenomena associated with vulcanism or with magma at depth in Long Valley caldera. Delineate type and magnitude of pressure response that would be expected in the ground-water system of Long Valley caldera prior to volcanic eruption. Revise the current conceptual model of the ground-water-flow system, including nonthermal and thermal aquifers, as new information becomes available. Measure land-surface deformation caused by geothermal fluid withdrawal and injection.

Approach: A network will be operated to monitor the levels, temperature, and quality of ground water; the quality of surface water; and the temperatures and composition of fumarole gas. Data will be assessed in relation to geologic events. A quantitative relation between change in ground-water pressure with strain in the aquifer matrix will be developed. Geologic and geophysical information obtained from other studies will be assimilated and used to revise the conceptual ground-water-flow model. Land-surface deformation will be measured annually by surveying bench marks in and near the geothermal well field at Casa Diablo.

Progress: A network of hydrologic monitoring sites was operated to provide data for assessing the response of the hydrologic system to magmatic or volcanic processes, seismic activity, and geothermal and water-supply developments. Data collection included measurements of ground-water levels, atmospheric pressure, water temperatures, discharge of springs and streams, precipitation and gas temperatures of fumaroles and chemical and isotopic analyses of water and gas samples. An open-file report presenting hydrologic data for 1987-93 is in colleague review.

Geothermal development at Casa Diablo has produced reservoir pressure changes that have caused localized land-surface deformation. Most of the deformation is land subsidence, which is countering the regional inflation caused by magma intrusion. A paper for the Journal of Geophysical Research, which describes deformation in a well field for 1988-1993, is in review. The Casa Diablo bench-mark network was resurveyed in July 1994. Aerial, thermal, infrared scanner data for Mammoth Mountain and Casa Diablo were collected during August 1994 under a contract with National Aeronautics and Space Administration.

A reconnaissance of four areas of tree-kill on Mammoth Mountain was done in July and September 1994. Analyses of soil gas collected at depths of 1 to 2 ft below land surface indicate concentrations of carbon dioxide of as much as 90 percent by volume. This high concentration of carbon dioxide is killing several tens of acres of coniferous forest in four areas. The carbon dioxide probably is related to a magmatic intrusion in 1989.

Plans for Fiscal Year 1995: Collection of data from the monitoring network will continue through 1995. If funding is available, higher precision ground-water-level monitoring equipment will be installed in the strain-monitoring well, LV-51. Data from the 1994 aerial infrared survey will be processed to identify thermal anomalies. Anomaly locations will be related to geologic structures and compared to areas with anomalous carbon dioxide discharge and tree-kill. A complete survey of carbon dioxide concentrations in soil and flux rates will be done for Mammoth Mountain. Results of this survey will be published in one or more journals.

Reports: None

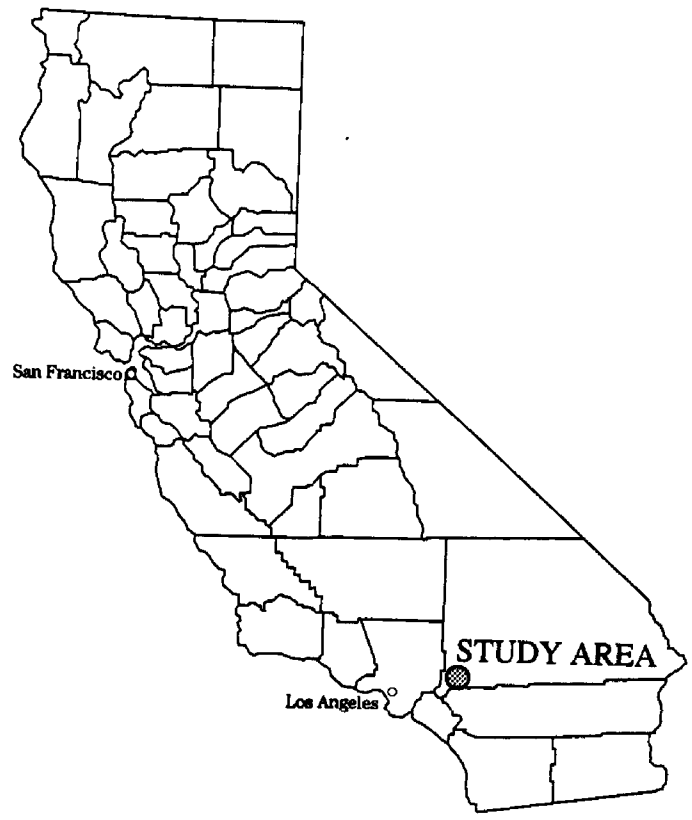
OPTIMUM MANAGEMENT IN A BASIN WITH CHANGING WATER-SUPPLY AND WATER-QUALITY PROBLEMS

Number: CA467

Cooperating Agency: San Bernardino Valley Municipal Water District

Project Chief: Wesley R. Danskin

Period of Project: October 1987 to September 1997



Problem: Historically, water purveyors have applied various techniques to solve water-supply and water-quality problems. Although most water purveyors rely on some form of conjunctive use of ground and surface waters, seldom is there optimum management of an entire water system. Improved management of complex hydrologic systems should be possible by developing and applying hydraulic- and economic-optimization techniques. But, to date, there has been little actual use of optimization techniques to solve real-world water-supply and water-quality problems.

Objectives: Develop and apply optimization techniques to demonstrate their usefulness in a real-world setting for conjunctive management of ground-water pumpage, ground-water levels, ground-water quality, and artificial ground-water recharge using surface water. Research will focus on developing new methodologies to incorporate system and parameter uncertainty in the optimization model.

Approach: Key aspects of the ground-water system will be verified to ensure accurate simulation with the existing ground-water-flow model. A surface-water distribution model will be designed and constructed. Critical water-quality problems and potential management options will be identified. A hydraulic/economic-optimization model will be developed that combines the surface- and ground-water models with the water-quality issues. New methods of water management will be evaluated.

Progress: In fiscal year 1994, work continued on the comprehensive hydrologic and modeling report which describes the results of the Bunker Hill basin project. In addition, work included training the cooperator staff on the use of the ground-water-flow model and analyzing potential changes in water management of the basin. An optimization training course was developed with the aid of findings from this study and taught at the U.S. Geological Survey National Training Center. An open-file report was written to document the response of ground-water levels throughout the western United States to major earthquakes in southern California. The report includes ground-water-level data collected from the multiple-depth piezometers in the San Bernardino area. New transducers were designed and procured from Parascientific to provide more accurate, long-term, nearly drift-free data for the 2-inch piezometers and to enhance present abilities to manage ground-water levels or monitor earthquakes. Reconnaissance of hydrogeologic data in the Yucaipa area began, available Geographic Information Systems (GIS) were reviewed, and local water purveyors were contacted.

Plans for Fiscal Year 1995: Investigations of the adjacent Yucaipa basin will be extended to include review of ground-water-quality data. A water-supply paper summarizing the hydrology and optimal management of the San Bernardino area will be reviewed. The open-file report documenting ground-water-level response to earthquakes will be submitted to the Director for approval; following approval the paper will be presented at a technical conference and published. Training of the cooperator on the use of the ground-water-flow and optimization models will continue.

Reports: None

RAINFALL AND RUNOFF IN THE ANTELOPE VALLEY, MOJAVE DESERT

Number: CA469

Cooperating Agency: Los Angeles County Department of Public Works; city of Palmdale; and U.S. Air Force, Edwards Air Force Base

Project Chief: James C. Blodgett

Period of Project: October 1987 to September 1999

Problem: Storm runoff in urbanized basins in Antelope Valley, California, is a major concern because increases in impervious areas in new developments cause increased runoff volumes and peak magnitude. The developing areas are on alluvial fans which commonly have high rates of infiltration. Reliable methods to estimate regional storm runoff are needed for land-use planning, land-development criteria, and design of drainage facilities. Several rainfall-runoff models are available for estimating runoff; however, there is a need to define the areal variation and relative significance of the input parameters to optimize the uses of these models.

Objectives: The primary objectives are to (1) apply a rainfall-runoff model appropriate for estimating design-storm characteristics in ungaged drainage basins in Antelope Valley and (2) estimate the frequency of runoff developed by regional analyses of streamflow data and compare those values with values obtained by long-term simulation. Specific objectives include (1) instrumentation and measurement of rainfall and runoff in eight drainage basins in Antelope Valley and (2) testing and comparison of several rainfall-runoff models to simulate measured runoff.

Approach: Eight basins that represent urbanized and nonurbanized conditions will be selected for collection of continuous-flow and precipitation data. Using these data and suitable historical data, selected rainfall-runoff models will be calibrated and results evaluated. Basins will be selected to provide three types of hydrologic data: flow magnitude, duration, and frequency; precipitation-runoff model calibration; and flow attenuation in a downstream direction. Aerial photography and infiltration measurements will be obtained to determine the characteristics of the basins for model application.

Progress: Data for the 1993 water year, which had the highest streamflows for 1990-93, were used to define ratings and to process records for prior years. Streamflow and precipitation were below normal during the 1994 water year; data for the 1994 water year will be processed in 1995. No rainfall-runoff analyses were made during the 1994 water year; however, analyses will be done in 1995. A report, which analyzes selected precipitation characteristics in Antelope Valley, was prepared.

Plans for Fiscal Year 1995: Rainfall-runoff data collected during the 1990-94 water years will be applied to rainfall-runoff models. The preliminary models will be calibrated using the revised basin boundaries, which were more correctly defined during floods in 1993. The rainfall-runoff models will be modified to include historical data for selected precipitation stations to compare results with historical runoff data. Because of the 1987-93 drought and the resulting lack of floodflow, the project has been extended to 1999. Six of the original eight precipitation stations will be used during the extended data-collection program.

Reports: None

DETAILED STUDY AND ASSESSMENT OF IRRIGATION DRAINAGE IN THE SALTON SEA AREA, IMPERIAL VALLEY

Number: CA470

Cooperating Agency: U.S. Department of the Interior

Project Chief: Roy A. Schroeder

Period of Project: Continuing

Problem: Selenium concentrations exceeding criteria for the protection of aquatic life were detected in irrigation drainage throughout the Imperial Valley. Elevated levels of selenium and DDT metabolites also were detected in fish and waterfowl at the National Wildlife Refuge (NWR). The elevated levels of selenium have resulted in restrictions on human consumption of fish from the Salton Sea.

Objectives: Determine the source, transport, and fate of selenium and other potential toxins in the Imperial Valley.

Approach: Water-quality samples were collected from 100 farm drain sumps for comparison with results of sampling done in 1986. Results were used to prepare concentration maps and to establish the relative importance of various hydrogeochemical processes. Twenty-one sites were monitored monthly to determine temporal variability. Lysimeter and piezometer data were evaluated to discern the interaction between drainwater and regional ground water. A range of representative environments for chemical residues in biota were measured to identify the trophic levels at which bioaccumulation of toxins occur.

Progress: The project chief participated in two interagency meetings of the National Irrigation Water-Quality Program. About 50 samples from 20 surface drains in the Imperial Valley were sampled for water and sediment quality in August 1994.

Plans for Fiscal Year 1995: The U.S. Geological Survey will continue to serve in an advisory capacity to the U.S. Bureau of Reclamation, which is now the lead agency for ongoing monitoring and mitigation or remediation efforts. Participation in interagency meetings of the National Irrigation Water-Quality Program will continue. Data from fiscal year 1994 sampling of surface drains will be compiled and given to the U.S. Bureau of Reclamation. The New River will be sampled for chemical analyses and for sediment and biota during the winter and summer.

Reports: None

CHANGES IN RUNOFF IN PERRIS VALLEY, RIVERSIDE COUNTY

Number: CA472

Cooperating Agency: Riverside County Flood Control and Water Conservation District

Project Chief: Joel R. Guay

Period of Project: October 1988 to September 1994

Problem: Increased urbanization in Perris Valley since 1970 has caused appreciable changes in runoff characteristics. The additional impervious area has resulted in increased runoff volumes and peak discharges. Few studies have documented what effect urbanization has on runoff characteristics. Because rainfall-runoff data for Perris Valley prior to urbanization are available, a current study could determine how urbanization has affected runoff characteristics in Perris Valley.

Objectives: Compare current runoff characteristics in urbanized Perris Valley with runoff characteristics prior to urbanization.

Approach: Rainfall-runoff data collected from 1989 to 1993 will be used to calibrate and verify a rainfall-runoff model. A rainfall-runoff model also will be calibrated and verified using the 1970-75 rainfall-runoff data. The results of the two models will be compared to estimate the effects of urbanization on runoff characteristics.

Progress: A report describing the results of a study on the effects of urbanization on storm runoff was written and is being prepared for colleague review. A long-term runoff record was simulated using rainfall-runoff models for 1970-75 and 1990-93 study periods and 45 years of hourly rainfall data. A frequency analysis of the simulated annual peak discharges for the two study periods indicated that the 2-year peak discharge doubled from 1970 to 1993. However, annual peaks with return periods greater than 50 years were the same for each study period, indicating that increased urbanization since 1970 has had little effect on the larger peak discharges.

Plans for Fiscal Year 1995: The report will be sent out for colleague review and then submitted to the Director for approval for publication.

Reports: None

GROUND-WATER HYDRAULICS IN WOLF VALLEY, RIVERSIDE COUNTY

Number: CA474

Cooperating Agency: Pechanga Indian Reservation/ Bureau of Indian Affairs

Project Chief: Charles A. Kaehler

Period of Project: October 1988 to September 1994

Problem: Both population and water use are increasing rapidly in the upper Santa Margarita River basin, Riverside County, California. In Wolf Valley, there is concern that future pumping will cause ground-water levels to decline and will deplete ground-water storage beneath the Pechanga Indian Reservation, especially beneath the Kelsey Tract of the reservation. Much of the water for the reservation is produced from an upper alluvial aquifer system, and most of the larger wells in the valley pump water from the lower aquifer system, which is separated from the upper aquifer system in some places by a confining bed.

Objectives: To develop a greater understanding of the ground-water hydraulics in the multiple-aquifer system of Wolf Valley. To collect additional hydrologic data, conduct aquifer tests, and evaluate aquifer response to pumping using the results of the aquifer test. To evaluate the effects of pumping on ground-water levels and storage and the nature of the hydraulic connection between aquifer systems beneath Kelsey Tract of the Pechanga Indian Reservation.

Approach: All available data on well construction, aquifer tests, subsurface geology, and historical water levels for Wolf Valley will be compiled. The existing water-level monitoring program will continue. Water levels in all available wells will be measured each autumn and spring. Four or five test holes will be drilled and logged to supplement existing geologic data. Two or more nested piezometers will be installed near a large-capacity production well and will be used during a long-term aquifer test to estimate the hydraulic properties of the lower and upper aquifer systems and of the confining bed. Knowledge gained on the ground-water hydraulics of the valley will be used to evaluate aquifer response to pumping.

Progress: In fiscal year 1994, monitoring of the recovery phase of the long-term aquifer test was completed. Raw data from the aquifer test were checked, corrected, converted to time-drawdown values, and graphed. The data were analyzed using a least-squares parameter estimation model that included well-bore storage, leakage from storage from fine-grained layers, and leakage from overlying aquifers. Results of the aquifer-test analysis were used to calculate the hydraulic properties of the aquifer system. In addition, this analysis provides new insight into the structural complexity of the aquifer system in central Wolf Valley and on the importance of the contribution of water from compressible storage in confining layers and from leakage from the unpumped aquifer system. The final report for this study was written and submitted for review.

Plans for Fiscal Year 1995: The final report will be submitted for Director's approval.

Reports: None

DEVELOPMENT OF SACRAMENTO RIVER BED-SCOUR RELATION AT THE SR-32 BRIDGE AT HAMILTON CITY

Number: CA476

Cooperating Agency: California Department of Transportation

Project Chief: James C. Blodgett

Period of Project: October 1988 to June 1994

Problem: Exposure or undermining of the bridge pier and abutment foundations from the erosive action of flowing water at the State Route 32 bridge at Hamilton City, California, can result in bridge failure or the need for expensive repairs. Bridge-scour data are difficult to obtain, partly because major scour usually occurs during flood conditions. As a result, actual measurements of scour, which can be used to define significant bridge and channel characteristics causing scour, and a comparison of scour data with laboratory derived relations are needed.

Objectives: Determine those hydraulic and bridge geometric factors that are important in the cause and extent of channel-bed scour. Develop equations to predict depth and lateral extent of scour at the old and new bridges and compare these equations with scour equations for other sites. Determine the rate of channel stabilization associated with constriction and local scour at the new bridge.

Approach: Channel-survey data obtained near the old bridge site will be used to relate bridge geometry and to indicate typical channel conditions. Scour and hydraulic data at the new bridge will be collected about four times per year and stored: once before the flood season, twice during the flood season, and once after the flood season. Geophysical soundings will be obtained annually to provide information on the maximum depth of scour below the surveyed channel bed. Data will be analyzed and separated into the components of channel bed, constriction, and local scour. Constriction and local scour will be related to bridge geometry.

Progress: Channel-geometry and bridge-scour data were collected in October 1993. No data were collected during the 1993-94 flood season because flows were too low. In June (the end of the cooperator's fiscal year), the project was terminated.

Plans for Fiscal Year 1995: None. The project was terminated.

Reports: None

GROUND-WATER RESOURCE INVESTIGATIONS, EDWARDS AIR FORCE BASE

Number: CA477

Cooperating Agency: U.S. Air Force, Edwards Air Force Base

Project Chief: Devin L. Galloway

Period of Project: Continuing

Problem: Declining water levels, an apparent degradation in water quality, and an antiquated water-distribution system have resulted in a water shortage at Edwards Air Force Base. In addition, there has been widespread land-surface subsidence in the southwest part of the base, and an extensive system of cracks, fissures, and potholes has developed on Rogers Lake (dry). This has generated concern about the condition of the runways on the lakebed.

Objectives: Define the boundaries and areal extent of the ground-water system. Quantify the distribution of hydrologic properties. Determine the ground-water-flow paths in relation to existing pumping centers and known areas of subsurface contamination. Define water types for different aquifers. Develop a long-term ground-water monitoring program. Identify sites for development of future well fields. Determine the influence of ground-water withdrawals and declining ground-water levels on the areal extent and amounts of land-surface subsidence and the extent and cause(s) of fissures, cracks, and potholes on the lakebed.

Approach: Surface geophysical methods will be used to identify the geologic structure and boundaries of the ground-water basin. Nested piezometers will be installed to establish a multilevel monitoring network. Ground-water levels will be measured and water-quality samples will be collected. Aquifer tests will be done. Land subsidence and surface deformation will be assessed by geodetic surveys, aerial photography of the lakebed, and monumentation of selected fissures. Extensometers will be installed to measure the amount and rate of subsidence. A ground-water-flow model will be developed.

Progress: Ground-Water Monitoring Network: Ground-water levels were measured and recorded hourly at 14 piezometers on and around Rogers Lake. Hourly measurements of aquifer-system compaction were recorded at three borehole extensometers near the southern end of Rogers Lake. These data were processed and stored using ADAPS.

Rogers Lake Surveying: Several new transects were surveyed on Rogers Lake to determine the changing shape of the dry lakebed owing to land subsidence. These data were compiled with data for previous years to produce a preliminary digital relief map of the surface of Rogers Lake.

Ground-Water Flow Modeling: A regional steady-state flow model was developed at the Antelope Valley scale using MODFLOW. Pumpage and ground-water-level data were compiled for the region using ARC INFO. Potentiometric surface maps were prepared to calibrate the transient flow model using kriging and co-kriging techniques. A second model grid, smaller than grid for the Antelope Valley, was developed within the regional model for the Edwards Air Force Base area.

Plans for Fiscal Year 1995: Monitoring of the ground-water network will continue. Compaction and ground-water-level data for the period of record will be analyzed. Transient ground-water-flow models at the Antelope Valley and Edwards Air Force Base scale will be calibrated. Linkages between these models will be developed. Simulation of contaminant transport of conservative solutes will be done using particle tracking (MODPATH) at selected sites on the base, and on the basis of these simulations, estimates of travel times between points of interest will be completed.

Reports: None

EVALUATION OF SUBSIDENCE RATES AND PROCESSES IN SURFICIAL PEAT, SACRAMENTO-SAN JOAQUIN DELTA

Number: CA479

Cooperating Agency: California Department of Water Resources

Project Chief: Steven J. Deverel

Period of Project: October 1989 to September 1994

Problem: The Sacramento-San Joaquin Delta islands and tracts have been subsiding because of oxidation of organic soils at a rate of 1 to 3 inches per year since the drainage of the islands and tracts began in the early part of this century. Continued subsidence poses a threat to the integrity of the levee system and will increase the amount of energy required to maintain a low water table for crop production. Knowledge of the processes contributing to subsidence of these soils will provide a basis for water- and land-management strategies to mitigate subsidence.

Objectives: The overall goal of this study is to better understand the factors that affect organic soil loss in the Sacramento-San Joaquin Delta. Specifically, the objectives are to (1) quantify subsidence rates in organic soils at selected locations, (2) identify and quantitatively assess hydrologic and geochemical processes that affect carbon loss under different land- and water-management practices, and (3) assess the spatial and temporal variability of carbon loss.

Approach: An attempt will be made to quantify the processes contributing to carbon loss from the organic soils at several agricultural sites in the delta. Two of these processes are (1) respiration of organic carbon and (2) dissolution and mobilization of aqueous-dissolved and particulate organic carbon. These processes will be assessed in conjunction with subsidence measurements at each site. A carbon mass-balance approach will be taken at each site to reconcile subsidence with carbon loss.

Progress: A data report was reviewed by colleagues and is being prepared for submittal to Headquarter's for approval, a water-fact sheet was approved by Headquarters for publication, and the two-part journal articles were resubmitted to the Soil Science Society of America Journal. The project is complete except for report.

Plans for Fiscal Year 1995: The data report will be submitted to the Director for approval for publication.

Reports: None

PROCESSES GOVERNING THE DISTRIBUTION AND MOBILITY OF SELENIUM AND ARSENIC IN SHALLOW GROUND WATER, TULARE BASIN

Number: CA481

Cooperating Agency: California Department of Water Resources

Project Chief: Roger Fujii

Period of Project: October 1989 to September 1995

Problem: Large parts of the Tulare basin are affected by shallow ground water, leading to a need for subsurface drainage for continued agricultural production. Disposal of agricultural drainwater in evaporation ponds and potential downward migration of contaminated, shallow ground water to regional aquifers have been a source of concern for migratory waterfowl and human health because of the high concentrations of arsenic and selenium in the drainwater. The diversity and contrast of depositional environments has contributed to the highly variable concentrations of arsenic and selenium in shallow ground water throughout the basin.

Objectives: Compare distribution of arsenic, selenium, and other selected elements in ground water and sediments at four locations in subareas of the Tulare basin. Identify geochemical, biological, and hydrologic processes controlling the solubility and mobility of arsenic and selenium at each location. Compare and contrast the potential influence of key processes among the subareas. Determine the studies necessary to comprehensively evaluate the geochemical, biological, and hydrologic processes governing solubility and mobility of arsenic and selenium in the subareas of this basin.

Approach: The distribution of arsenic and selenium in ground water and sediments will be evaluated at four locations in the basin. At each site, 20-, 50-, 100-, and 200-foot wells will be drilled and sampled. During drilling of the 100-foot well, a continuous core will be taken and porewater and sediment will be analyzed every 5 to 10 feet. Samples will be analyzed for arsenic, selenium, and other trace and major constituents. Water levels will be monitored. These data will help to define the key processes that affect the mobility of arsenic and selenium and to form the basis for further studies in the basin.

Progress: Extractions of selected sediment samples from three sites were completed and the samples were analyzed. Three reports were written and are at various stages of review.

Plans for Fiscal Year 1995: Data from the extraction experiments will be analyzed, and a report will be written on the results of this analysis. The three other reports will be submitted to the Director for approval for publication.

Reports: None

SAN FRANCISCO BAY-ESTUARY TOXIC CONTAMINANTS STUDY

Number: CA484

Cooperating Agency: U.S. Geological Survey Federal Program; U.S. Environmental Agency; and California Water Resources Control Board

Project Chief: Kathryn M. Kuivila

Period of Project: March 1990 to September 1995

Problem: Estuaries are among the most heavily used of the Nation's surface-water resources and are particularly susceptible to contamination by toxic substances. The San Francisco Bay estuary receives a broad range of organic contaminants that vary widely in their sources, seasonality, toxicity, and environmental behavior. Despite an increasing awareness of potential contamination issues, the effect of organic contaminants in the estuarine environment is not fully understood.

Objectives: Determine how organic contaminants from riverine and local sources are transported and how they react in the estuary under varying hydrologic conditions. Determine the ultimate fate of these organic contaminants within the estuary. Develop methods to detect and quantify ecological responses to the presence of organic contaminants in the estuary.

Approach: Present data on pesticide use and waste discharges will be synthesized to select specific organic contaminants for sampling and analysis. Various sampling techniques will be used, including fixed-site monitoring and synoptic studies, to provide a consistent record of river-transported contaminants. Certain hypotheses on contaminant distribution during specific hydrologic and contaminant-loading conditions will be tested. Bottom sediment and biota will be collected and analyzed to define the distribution of these contaminants and their partitioning between water, sediment, and biota.

Progress: Research studies for this fiscal year focused on: (1) transport of dissolved and sediment-bound pesticides into Suisun Bay, (2) degradation rates of select pesticides under in situ conditions, and (3) pesticide concentrations in the delta. Pulses of diazinon and methidathion, similar to those observed the previous year, but at lower concentrations, were detected in the Sacramento River at Sacramento and in the San Joaquin River at Vernalis following rainfall in January and February. Concentrations of suspended sediment peaked concurrently at both sites. Samples of suspended sediment collected during peak concentration are being analyzed for adsorbed pesticides. Laboratory mesocosm experiments were used to estimate the total degradation rates of select pesticides in the Sacramento and San Joaquin Rivers and the San Pablo Bay (15 parts per thousand salinity) water. These results will be used to determine the importance of microbial degradation, salinity, and dissolved organic carbon to total rates of degradation. Concentrations of dissolved pesticides and dissolved organic carbon were measured at 30 sites within the delta in June and September. A report on quality assurance and the chemical quality of pesticide analysis in the Sacramento Laboratory was written by Kathryn Crepeau and approved by the Director for publication. A report was written presenting data from a study to monitor pesticide concentrations in the Sacramento River at Sacramento and the San Joaquin River at Vernalis from January 1991 through April 1994. A journal article was written on pesticide concentrations and transport in the delta and San Francisco Bay following rainfall and was accepted by the Journal of Environmental Toxicology and Chemistry. Two presentations were given at the American Chemical Society Meeting in March and one presentation was given at the Northern California chapter of the Society of Environmental Toxicology and Chemistry meeting.

Plans for Fiscal Year 1995: The emphasis for next fiscal year will be on sampling and analyzing sediment-bound pesticides in the Sacramento River and the Suisun Bay to determine factors that control degradation rates and to study the transport of dissolved pesticides and dissolved organic carbon in the delta. Journal articles on the long-term pesticide monitoring at Sacramento and Vernalis and on concentrations of rice pesticides in the Sacramento River from 1991-93 will be completed.

Reports:

Kuivila, K.M., and Crepeau, 1994, Transport of diazinon in the Sacramento-San Joaquin Delta, California (abs.): American Chemical Society National Meeting, San Diego, California, March 13-18, 1994.

SAN JOAQUIN-TULARE BASINS NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Number: CA485

Cooperating Agency: None. (U.S. Geological Survey Federal Program)

Project Chief: Neil M. Dubrovsky

Period of Project: Continuing

Problem: The quality of the Nation's water is being degraded by various human and natural processes. A large amount of water-quality data has been collected to assess the effect of point sources and compliance with regulations. In contrast, the effect of nonpoint sources is significant but rarely studied. Existing data generally are inadequate to assess the status and trends in water quality of large regions and the Nation. Additional data need to be collected to address questions about water quality and to determine the effect of regulatory practices and past water-quality management decisions.

Objectives: (1) Provide a description of current water-quality conditions consistent with the needs of the national level synthesis of the data; (2) define long-term trends (if any) in water-quality data; and (3) identify, describe, and explain to the extent possible the major human and natural factors that affect observed water-quality conditions and trends. Key factors of concern in the study unit are concentrations of pesticides, nutrients, and naturally occurring trace elements in surface and ground water and surface-water salinity.

Approach: During the first phase an extensive retrospective analysis of the status and trends in water quality and aquatic ecology will be done using existing data. A reconnaissance will be done concurrently to collect data on aspects of water quality for which little or no data exist. These two activities will identify areas where there is insufficient data for water-quality assessment and will provide the basis for design of a 3-year intensive data-collection phase. A long-term network will consist of a carefully selected subset of the stations sampled during the intensive phase.

Progress: During fiscal year 1994, pesticide transport in surface water from the eastern tributaries of the San Joaquin River during high flows was studied. A dye tracer test was run concurrent with the water-quality sampling so that the contribution of pesticides from various sources to the total pesticide load at the mouth of the San Joaquin River could be evaluated. In addition, suspended-sediment samples were collected from western tributaries of the San Joaquin River for analysis of organochlorine pesticide residues, a pesticide synoptic was done during the period of peak summer pesticide use, and water-quality monitoring at the Basic Fixed Station continued. A synoptic ecological study of the eastern tributaries to the San Joaquin River also was done. Samples were collected from 20 shallow domestic wells in areas of almond cultivation for a "Land-Use Study" on the effect of land use on the quality of shallow ground water. These data will be compared with water-quality data for 10 observation wells that were installed adjacent to a subset of domestic wells. In addition, 11 wells were installed and sampled as part of the NAWQA "Flow-Path Study" on geochemical processes in ground water underlying vineyards in eastern Fresno County (see Project CA507).

Plans for Fiscal Year 1995: Monitoring of surface-water quality will conclude early in fiscal year 1995. A synoptic, designed to differentiate between urban and agricultural sources of pesticides to the Tuolumne River during winter runoff, will be done. Samples of suspended sediment will be collected from western tributaries during a winter storm to complete the study on the transport of sediment-bound pesticides. Ecological surveys will be done to examine spatial and temporal variability of ecological characteristics at three sites. Water-quality samples will be collected from 20 domestic wells in areas of alfalfa, corn, and vegetable cultivation for the "Land-Use Study." This data will be supplemented with data from 10 observation wells. Additional wells will be installed and sampled for water quality at the "Flow-Path Study" sites, and a ground-water-flow and transport model will be constructed (in cooperation with project CA507).

Reports:

Gronberg, J.M., and Knifong, D.L., 1994, Use of Geographic Information System in analyzing land-use effects on ground-water quality, San Joaquin-Tulare Basins, California: American Water Resources Association, Jackson Hole, Wyoming, June 27-29, 1994, Poster.

Knifong, D.L., and Gronberg, J.M., 1994, Basin fixed site selection and monitoring, San Joaquin-Tulare Basins, National Water-Quality Assessment Program, U.S. Geological Survey: Environmental System Research Institute, Palm Springs, California, May 23-27, 1994, Poster.

Kratzer, C.R., 1994, Nitrate in surface water in the San Joaquin Valley drainage basin, California: A retrospective assessment (abs.): American Water Resources Association, Annual Summer Symposium, Effects of human-induced changes on hydrologic systems, Jackson Hole, Wyoming, June 26-29, 1994, Program, p. 1164.

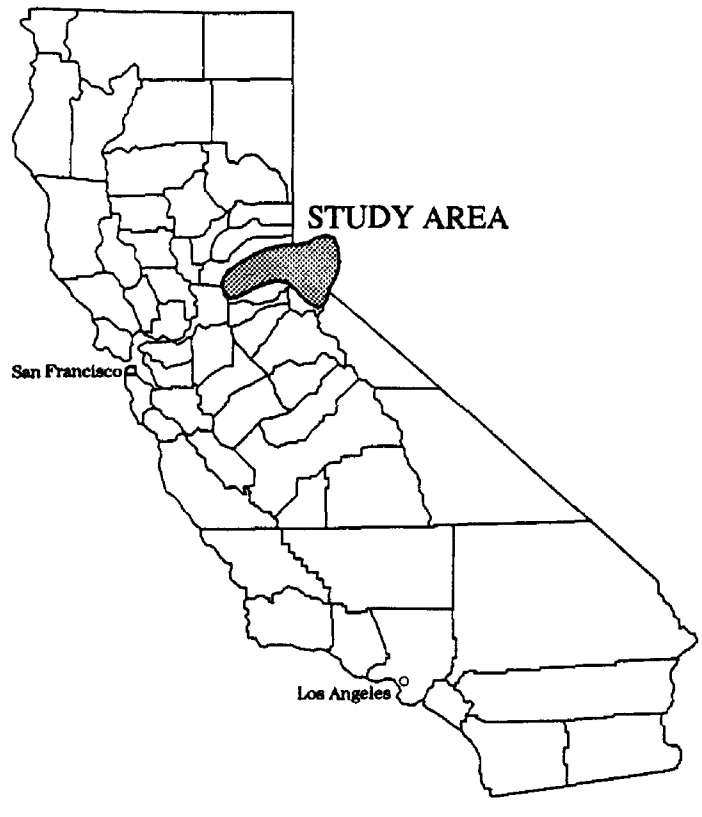
ASSESSMENT OF THE EFFECTS OF POTENTIAL CLIMATE CHANGE ON THE WATER RESOURCES OF THE CARSON AND AMERICAN RIVER BASINS

Number: CA488

Cooperating Agency: None. (U.S. Geological Survey Federal Program)

Project Chief: Michael D. Dettinger

Period of Project: March 1990 to September 1995



Problem: Changes in current climatic patterns could have significant effects on the type, amount, and timing of precipitation and runoff in the Carson and American River basins. Significant changes could result in far-reaching effects on hydrologic processes, biota, water management, and water use. These same "effects" may tend to influence the forms that climate change (tendencies toward wetter, drier, warmer, or cooler seasons) could take.

Objectives: Define the effects of possible climate change on the water resources of the Carson and American River basins and develop analytical tools for analysis of the effects of climate change on water resources elsewhere. In fiscal year 1994, the scope of the study will be broadened to define the interactions and feedback between large-scale climate systems (continental) and regional-scale hydrology, especially in the midcontinent region of North America.

Approach: The study was a joint effort between the California and Nevada Districts of the U.S. Geological Survey to describe the current climate and to develop future climate scenarios, a data base to support watershed modeling, and a model of watershed processes for current and future scenarios. Beginning in fiscal year 1994, a conceptual land-air interaction model will be developed linking a land-surface hydrologic model with a planetary boundary-layer model. The overlying atmosphere will not be modeled but specified instead. Such a model should support the development of a theory for time and distance scales at which hydrologic systems and climatic systems can and do interact.

Progress: A clear-sky model of the land-surface and planetary boundary-layer (PLB) system has been developed. The model includes a vigorous diurnal cycle and fair-weather clouds, heat and moisture advection, longwave radiative cooling, surface heat and moisture fluxes, and mixing with the overlying atmosphere. This model includes processes not in comparable models and so was compared to field data rather than other models as previously was planned. However, field data which are detailed enough for testing the model is uncommon so, initially, the model was compared with field data from Kansas for the summer 1987. Three major journal articles on the Sierra Nevada modeling efforts were published, and two more articles were submitted to journals.

Plans for Fiscal Year 1995: Improvements to land-surface and cloud/precipitation representations in the land-planetary boundary-layer model are planned, and more detailed comparisons to field data will be done. A journal article describing the model and the initial results of the model will be drafted.

Reports:

Dettinger, M.D., Cayan, D.R., and McCabe, G.J., 1994, Decadal trend in runoff over the western United States and links to persistent North Pacific sea-surface temperature and atmospheric-circulation patterns, *in* Proceedings of the Eighteenth Annual Climate Diagnostics Workshop, Boulder, Colorado, November 1-5, 1993: Boulder, Colo., National Oceanic and Atmospheric Association, p. 240-243.

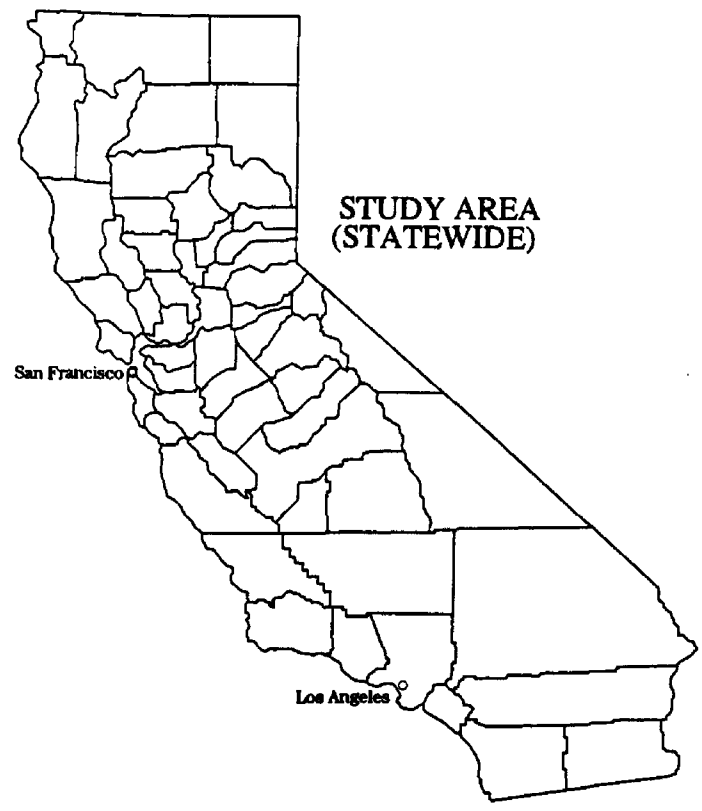
NATIONAL WATER-QUALITY ASSESSMENT PROGRAM--NATIONAL SYNTHESES

Number: CA491

Cooperating Agency: None. (U.S. Geological Survey Federal Program)

Project Chief: Robert J. Gilliom

Period of Project: Continuing



Problem: Protecting the quality of the Nation's ground- and surface-water resources is a high-priority national concern. The quality of these resources can affect public health and the economics of agriculture, industry, fish and shellfish, and recreation. At present, there is no unified and consistent program for national water-quality assessment. Without such a program, policy decisions must be made on the basis of extrapolations from knowledge of a few localized problems and in ignorance of other types of problems that may be unknown because no one has investigated them at the right times and places.

Objectives: Define the quality of the Nation's ground- and surface-water resources through a continuing assessment program of nationwide scope that would (1) describe the status and temporal trends in water quality and (2) improve the understanding of factors that influence water quality and thereby provide a basis to forecast change and evaluate the likely effect of various proposed remedial and protective actions on water quality.

Approach: The program is a national perennial program of water-quality data acquisition, interpretation, and assessment. Activity will be clustered into study units that are widely scattered around the Nation but which, in aggregate, account for a large percentage of the Nation's water use. A nationally consistent set of target water-quality variables will be studied. The work and reporting of results will be done at three scales: national, regional, and study unit.

Progress: Analyses of existing data on pesticides continued. A detailed design for the national synthesis data analysis is being developed. Analyses of new data from the National Water-Quality Assessment Program study units started. A report on national standards and guidelines for pesticides in water, sediment, and aquatic organisms was published. Reports on existing data will be submitted for approval for publication, and reports on the new data will be prepared for review.

Plans for Fiscal Year 1995: Analyses of existing data will be completed. New data from the National Water-Quality Assessment Program study units will be the primary emphasis of analyses during fiscal year 1995.

Reports:

Barbash, J.E., 1994, The use of solute-transport models and vulnerability assessments for predicting the behavior of pesticides in the subsurface (abs.): American Chemical Society Meeting, 208th, Tissues in quantitative assessment of environmental fate and exposure, Washington, D.C., August 21, 1994, part, not paginated.

Majewski, M.S., 1994, Overview of existing information on occurrence and distribution of pesticides in the atmosphere (abs.): International River Quality Symposium, Portland, Oregon, March 21-24, 1994, Program.

Nowell, L.H., and Resek, E.A., 1994, Summary of National standards and uidelines for pesticides in water, bed sediment, and aquatic organisms and their application to water-quality assessments: U.S. Geological Survey Open-File Report 94-44, 115 p.

GROUND WATER, SOUTH SAN FRANCISCO BAY AREA

Number: CA493

Cooperating Agency: The San Francisco Bay Area Water Users Association; city of San Francisco; San Francisco Water Department; and city of Atherton

Project Chief: John L. Fio

Period of Project: January 1991 to September 1996

Problem: The south San Francisco Bay and peninsula area is one of the largest urban and industrial centers in northern California. Its water supply is primarily surface water from local and distant drainage basins. Availability of water is strongly affected by annual precipitation, runoff, and reservoir storage in the Sierra Nevada. An alternative source of water is needed to augment surface-water deliveries during droughts or following disasters that might disrupt deliveries and reduce supplies. Ground water in the underlying aquifer systems is a viable alternative, but the variability in aquifer characteristics and ground-water quality is poorly understood.

Objectives: The overall objective of the study is to assess the ground-water resources by (1) identifying geohydrologic boundaries, aquifer characteristics, storage volumes, and water budgets; (2) defining the chemical characteristics of ground water; and (3) identifying areas of potential subsidence, water logging, ground-water development, or areas that may benefit by conjunctive use of surface, ground, and reclaimed water.

Approach: An assessment of the hydraulic characteristics of the aquifer, the spatial distribution of water quality, and problems associated with ground-water withdrawal or recharge will be done. Reconnaissance-level assessments will be done by compiling data from earlier reports, maps, and existing well logs and from data on water and land use and water quality. These data will be entered into a geographic information system (GIS) data base. The data base will be augmented with information collected during this study and will be used to support local and regional assessments on ground-water storage, ground-water flow, and ground-water quality.

Progress: South San Francisco Bay and Peninsula Area: Two reports were approved by the Director and are being prepared for publication. The first report describes a regional assessment of the geohydrology and water quality of the south San Francisco Bay and peninsula area. The second report documents the structure, contents, and limitations of the GIS data base. Preliminary preparations for colleague review of a third report were completed; the report is being prepared for transmittal to the reviewers. This report describes the spatial distribution of water supply, discharge, and consumptive use in the south San Francisco Bay and peninsula area.

Southern San Mateo County: A network of more than 40 residential wells was developed within the town of Atherton to assess local geohydrologic conditions and ground-water quality in part of southern San Mateo County. These wells are used to routinely measure water levels and, where meters exist, to record cumulative pumpage. Water samples were collected from 20 wells and analyzed for major cations and anions. Land-surface elevations were measured at 18 locations. Results of the data collection are described and interpreted in a preliminary report that was transmitted for colleague review.

Menlo Park Area: Existing lithologic, water-level, and water-quality data for 541 wells and boreholes in the neighboring Menlo Park area were compiled and entered into the GIS data base. Preliminary maps of hydraulic-head contours were constructed using data from 1980-94. Preliminary figures and maps showing sediment texture, defined in this study as the function of coarse- and fine-grained sediment, also were constructed.

Plans for Fiscal Year 1995: The authors will respond to the colleague comments on the reports for the San Francisco Bay and peninsula area and southern San Mateo County; the reports will be submitted for Director's approval. Ongoing work in Atherton will include collecting water-level, cumulative-pumpage, and well-operation data. Water levels will be measured quarterly and pumpage data will be collected every other month. A transit-time flow meter will be purchased to measure discharge rates at accessible wells to improve estimates of annual pumpage in Atherton. The GIS data base is being used to construct digital files for the computer program MODFLOW. This program will be used to simulate average hydraulic heads and ground-water fluxes in the Atherton and Menlo Park areas.

Reports: None

EFFECTS OF WATER BANKING ON GROUND-WATER FLOW AND QUALITY IN THE RIALTO-COLTON BASIN, SAN BERNARDINO

Number: CA494

Cooperating Agency: San Bernardino Valley Municipal Water District

Project Chief: Linda R. Woolfenden

Period of Project: October 1991 through September 1995

Problem: Water banking is a key factor for meeting future water-supply needs in southern California. Historically, ground-water extractions have exceeded natural recharge in southern California, resulting in declining water levels and, in some areas, water-quality degradation. Using ground- water basins for water banking during wet periods will help solve southern California's water-supply problems. The Rialto-Colton basin has the potential for water banking because of its historically good quality of water, the known large capacity for ground-water storage in the basin, and the local availability of imported water.

Objectives: The objective of this study is to determine the effects of water banking on the local ground-water flow system and on ground-water quality near an existing artificial recharge site and basinwide. This will be accomplished by determining the movement and mixing of imported water at the existing artificial recharge site within the Rialto-Colton basin, defining basinwide ground-water hydraulics and ground-water quality, and predicting the movement and mixing of artificially recharged imported water.

Approach: The study tasks are to drill and complete eight multiple-depth wells, measure water levels and collect samples for chemical analyses for these wells and selected existing wells, conduct aquifer tests, develop a water budget, and simulate basinwide ground-water flow using a mathematical model. Data collected as a result of these tasks will contribute to the formulation of a conceptual model. The mathematical model will be used to verify the conceptual model and to assess the effects of artificially recharging imported water on basinwide ground-water flow and ground-water quality.

Progress: Drilling and construction of multiple-depth wells were completed. These wells, as well as selected existing wells installed for this project, were sampled for chemical analyses. Water was analyzed for major dissolved ions, oxygen and hydrogen isotopes, and carbon-14. Analysis of the oxygen and hydrogen isotope data was summarized in an American Water Resources Association conference proceedings paper entitled "Oxygen-18, Deuterium, and Tritium as Tracers of Imported Water in the Rialto-Colton Basin, California." Aquifer tests were done at four sites throughout the basin. Work on a mathematical model to simulate ground-water flow continued.

Plans for Fiscal Year 1995: Water-quality samples will be collected at the multiple-depth well site, which was completed in fiscal year 1994, and at two additional observation-well sites. Four production wells also will be sampled. Water levels at eight multiple-depth well sites will be measured with transducers and recorded by data loggers. Monthly servicing of the equipment and manual measuring of water levels, which were added to the data program, will be done. Aquifer-test data will be analyzed for aquifer properties. Data analysis, work on the ground-water-flow model, and report writing will continue.

Reports:

Woolfenden, L.R., 1994, Oxygen-18, deuterium, and tritium as tracers of imported water in the Rialto-Colton basin, California, in Proceedings on the Effects of human-induced changes on hydrologic systems, AWRA 1994 Annual Summer Symposium of the American Water Resources Association, Jackson Hole, Wyoming, June 26-29, 1994: American Water Resources Association Technical Publication Series TPS-94-3, p. 923-932.

GROUND-WATER HYDROLOGY AND TRACE-ELEMENT TRANSPORT IN FRACTURED ROCKS AT THE PENN MINE AND CAMANCHE RESERVOIR, CALAVERAS COUNTY

Number: CA495

Cooperating Agency: California Water Resources Control Board; and East Bay Municipal Utility District

Project Chief: Charles N. Alpers

Period of Project: October 1991 to December 1995

Problem: Penn Mine is an abandoned copper-zinc mine in northwestern Calaveras County, California. Mining activity from the 1860's to 1950's left nearly 1 million tons of waste rock and tailings exposed in surface piles. In 1979, seven unlined wastewater ponds were built by the East Bay Municipal Utility District and California Regional Water Quality Control Board--Central Valley Region to capture contaminated runoff from the site. Parts of the largest pond likely recharge the underlying aquifer of fractured metavolcanic rock. Remediation of acid drainage will depend on achieving a better understanding of ground-water hydrology and trace-element transport.

Objectives: Determine ground-water-flow patterns near the Penn Mine site with emphasis on the fractured metavolcanic-rock aquifer and quantify interactions with Camanche Reservoir. Characterize the geochemistry of the ground-water system and determine important physical and geochemical processes that control the distributions of major constituents and trace elements. Determine the stable isotope composition of water and dissolved sulfate in ground water from the mine workings and in the acidic plume between Penn Mine and Camanche Reservoir and evaluate mixing of water from mine workings and wastewater ponds. Quantify the transport of major constituents and trace elements along flow paths from the mine site to Camanche Reservoir.

Approach: Detailed hydrogeologic and geochemical investigations began between Penn Mine and Camanche Reservoir. Surface mapping and surface and downhole geophysics will be used to determine orientation, density, and location of fractures. Downhole flow-meter measurements will determine zones with flowing fractures; selected zones will be isolated using inflatable packers and sampled separately for water quality and hydraulic conductivity. Water-rock interactions will be assessed using mass-balance calculations and supplemented with speciation-saturation and mass-transfer calculations.

Progress: Geophysical borehole logs were obtained for six of the monitoring wells drilled during November 1992. Downhole flow-meter tests were done at three of the wells; the tests showed significant flowing fractures at one of the wells. Water samples were collected from 13 wells in December 1993 and from 10 wells in May and June 1994. An aquifer test was done at one well during May 1994, after which a tracer test was done by injection of lithium bromide at a well upgradient from the well at which the aquifer test was done. Preliminary results of chlorofluorocarbons and tritium dating indicated that ground water in the acidic plume is relatively young, as was expected. Analysis of 34-S/32-S and 18-O/16-O in dissolved sulfite demonstrated the value of these ratios as tracers for sulfite and indicated active, sulfate reduction processes in the underground mine workings.

Plans for Fiscal Year 1995: Pending funding from cooperative agencies, plans include one additional sampling at selected wells and the evaluation of the tracer test done in May 1994. The evaluation will be done using a one-dimensional flow model. The final report will be written as well as journal articles describing results of stable isotope analyses.

Reports:

Alpers, C.N., and Blowes, D.W., editors, 1994, Preface to Environmental geochemistry of sulfide oxidation, American Chemistry Society Symposium series 550: Washington, D.C., American Chemical Society, p. xiii-xiv.

Alpers, C.N., Nordstrom, D.K., and Thompson, J.M., 1994, Seasonal variations of Zn/Cu ratios in acid mine water from Iron Mountain, California, *in* Alpers, C.N., and Blowes, D.W., eds., Environmental geochemistry of sulfide oxidation, American Chemistry Society Symposium series 550: Washington, D.C., American Chemical Society, p. 324-344.

EVALUATION OF CARBON FLUXES IN FLOODED ORGANIC SOILS IN THE SACRAMENTO-SAN JOAQUIN DELTA

Number: CA496

Cooperating Agency: California Department of Water Resources

Project Chief: Bronwen Wang

Period of Project: October 1991 to September 1995

Problem: Much of the land surface in the Sacramento-San Joaquin Delta has subsided below sea level. This subsidence primarily is due to oxidation of the organic soils, which were drained in the early 1900's. To prevent further subsidence and possible levee failure, the California Department of Water Resources plans to inundate islands in the western delta. An understanding of the changes in island elevations and the aqueous and gaseous carbon fluxes in these resubmerged organic soils will contribute to the development of water- and land-management practices to minimize land subsidence.

Objectives: The overall objective is to determine the effects of different water- and land-management practices on land subsidence and on aqueous and gaseous carbon fluxes in organic soils. Specific objectives of the study are to (1) quantify aqueous and gaseous carbon fluxes under different water- and land-management regimes, (2) determine the biogeochemical processes controlling these carbon fluxes, (3) assess the effects of different water- and land-management practices on these biogeochemical processes, and (4) assess the effects of different water- and land-management practices on subsidence.

Approach: Changes in island elevations and aqueous and gaseous carbon fluxes will be quantified and predominant biogeochemical processes will be identified under different water- and land-management practices. Specific study elements include (1) island-elevation-change measurements using extensometers, (2) assessment of aqueous and gaseous carbon fluxes by IR-total organic carbon analysis and gas chromatography, and (3) assessment of the biogeochemical pathways from carbon, hydrogen, and oxygen isotope composition.

Progress: Measurement of surface elevations to evaluate the effects of different water-management strategies on land-surface elevation continued. Monitoring of the ponds continued with changes in gaseous carbon flux during this second year of the water-management program similar to changes that occurred during the first year of the program. Short-term decreases in carbon-dioxide flux in the moist pond were measured after each irrigation. No significant difference was measured in gaseous carbon flux in the moist, seasonal, and control ponds, but significantly less gaseous carbon was emitted under flooded conditions. The primary gaseous-carbon- containing species were carbon dioxide for the moist, seasonal, and control ponds and methane for the flooded site. Carbon input for all three ponds was not significantly different. These input values represent the maximum carbon input possible and assume that all the biomass from one growing season would be added to the ponds in the same season (for example, no plants persist to the next growing season). Yearly carbon loss for the ponds can be calculated from the mean gaseous carbon fluxes from the three ponds. Then, if all the biomass carbon is assumed to be added to the system, the difference between the carbon input and loss can be calculated. Under these conditions, carbon loss exceeds input for the moist and seasonal ponds, but the input exceeds loss for the flooded pond.

Plans for Fiscal Year 1995: Reduced monitoring of the ponds will continue through the 1995 fiscal year. Laboratory experiments will be continued to evaluate depth of flooding and wetting and drying cycles on carbon flux. In addition, column studies to evaluate the effect of inorganic capping materials will begin. During fiscal year 1995, work primarily will be focused on the production of reports.

Reports: None

GROUND-WATER AND SURFACE-WATER RELATIONS ALONG THE MOJAVE RIVER

Number: CA497

Cooperating Agency: Mojave Water Agency

Project Chief: Gregory C. Lines

Period of Project: October 1991 to September 1995

Problem: Water supply for the Mojave River basin is derived mainly from ground-water pumpage; most of the ground-water recharge in the basin is from the Mojave River. A thorough understanding of ground- and surface-water relations is essential for future management and use of local and imported water and to evaluate management options for artificial recharge along the river.

Objectives: Document the sources and quantities of historical ground-water recharge and discharge along the Mojave River. Define hydraulic conditions that control the exchange of water between the river and the ground-water system. Identify reaches of the river suitable for artificial recharge.

Approach: Historical recharge from the Mojave River will be estimated using discharge records from gaging stations and water-level measurements from wells. Phreatophytes will be mapped using aerial photographs, and ground-water pumpage will be determined from reported values and from water requirements for agricultural and municipal use. Hydraulic conditions controlling exchange of water between the river and river deposits will be quantified by infiltrometer tests, observation-well and gaging-station data, and channel and flood-plain geometry.

Progress: During the third year of this study, work primarily consisted of analysis of streamflow records for five gaging stations on the Mojave River. Hydrograph-separation techniques were used to determine annual storm flow and base flow (ground-water discharge) for 1931-93. Streamflow hydrographs were used to estimate seasonal and long-term streamflow depletion owing to ground-water pumpage and evapotranspiration. Channel geometry was measured at 29 gaging stations throughout the Mojave Desert region to determine the relation between channel width and average discharge. This relation then was applied to the channel widths of the major ephemeral tributaries of the Mojave River to estimate ungaged runoff between gaging stations.

Plans for Fiscal Year 1995: During the last year of the study, work primarily will consist of preparation of the final interpretive report for review. Colleague review of the report is scheduled to begin in April 1995.

Reports: None

DENITRIFICATION, ATTENUATION OF ORGANIC COMPOUNDS, AND COLLOID TRANSPORT BENEATH A RECLAIMED-WATER ARTIFICIAL RECHARGE BASIN

Number: CA498

Cooperating Agency: Water Replenishment District of Southern California

Project Chief: Terry F. Rees

Period of Project: October 1992 through September 1996

Problem: A shortage of water for Los Angeles County has increased pressure to use reclaimed water to recharge ground-water basins. Reclaimed water frequently has increased concentrations of nitrogen compounds, total organic carbon, colloid organic carbon, colloid-associated metals, bacteria, viruses, and other colloids. Developing water-quality standards for recharge of reclaimed water requires knowledge of the degree to which these substances are removed as water percolates through the unsaturated zone and, assuming they reach the water table, what geochemical and biological reactions and transport properties control their concentrations as they move through the aquifer to the point of withdrawal.

Objectives: Determine the distribution of nitrogen species, TOC, COC, CAM, and bacteria and viruses in the unsaturated zone beneath an artificial recharge basin using reclaimed water. Determine the amount of denitrification and colloid attenuation occurring in the unsaturated zone. Determine the physical and chemical fractionation of TOC, COC, CAM, and bacteria and viruses in water as they move through the unsaturated zone. To the degree funding allows, determine the chemical fractionation of these constituents as they move through the unsaturated zone.

Approach: A literature review will be done. Continuous cores will be collected at the start and finish of the project and will be analyzed for lithology, water content, porewater chemistry, and bacteria and virus populations. At least one multiple-completion well in the unsaturated zone will be installed beneath the basin. Unsaturated zone instrumentation will include various types of lysimeters, gas sampling tubes, and a multilevel sampler. A neutron access tube will be installed to monitor water movement in the unsaturated zone. Upgradient and downgradient multiple-completion wells will be installed to monitor mixing in the saturated zone. Physical fractionation will be determined using centrifugation, ultrafiltration, and tangetial-flow filtration.

Progress: Three major sampling campaigns were completed during fiscal year 1994. Results of the first sampling campaign were used to help explain the biogeochemical behavior of the artificial recharge basin after it had reached equilibrium after initial recharge. Because of heavy rainfall during the winter prior to the first campaign, the water table was above the floor of the basin and therefore there was no unsaturated zone. During the second campaign, basin characteristics were studied when hydraulic conditions were more normal, that is, when there was an unsaturated zone, and the time required for the basin to come to equilibrium after being recharged with reclaimed water was determined. During the third campaign when the basin was at equilibrium, biochemical reactions were studied as the infiltrated water moved downgradient from the basin.

During the filling of the basin and for a period of 5-7 days after the basin reached capacity, there was little change in water quality as the water percolated through the soil column to the water table. After the 5-7 days, the concentrations of total N and DOC began to decrease significantly, and after 7 days, most of the N and DOC was removed prior to reaching the water table.

Plans for Fiscal Year 1995: Journal articles and the final interpretive report will be prepared for Director's approval.

Reports: None

SOUTH SAN FRANCISCO BAY SEDIMENT PROCESSES

Number: CA499

Cooperating Agency: San Francisco Bay Regional Water Quality Control Board

Project Chief: David H. Schoellhamer

Period of Project: October 1992 to July 1996

Problem: Estuaries are areas of accumulation of fine-sediment particles that may include adsorbed trace metals and organic compounds. Concentrations of the trace metals and organic compounds in the accumulated estuarine sediments can reach levels that are toxic to benthic organisms. The cycle of sediment deposition, resuspension, transport, and redeposition leads to a long estuarine residence time for the fine-sediment particles and adsorbed substances. Thus, the residence time of many toxic substances in estuaries, as well as organism exposure to these substances, is strongly related to the transport of the fine-sediment particles.

Objectives: The primary objective is to assess quantitatively the processes that affect the transport of suspended sediment and trace metals in South San Francisco Bay. Specific objectives are to (1) identify the processes that result in resuspension and transport of sediment in south San Francisco Bay, (2) quantify the effects of these processes on sediment residence times during low-inflow periods, and (3) determine if sediment resuspension affects dissolved concentrations of silver, cadmium, copper, and zinc.

Approach: Time-series data for suspended-solids concentrations will be collected at several sites and analyzed to identify sediment resuspension and transport processes in South Bay. A tidal hydrodynamic model with Lagrangian particle tracking will be used to assess the increase in summer residence times of adsorbed trace metals caused by sediment deposition and resuspension. The effect of sediment resuspension processes on dissolved-metals concentrations will be evaluated by analyzing dissolved concentrations of silver (a contaminant of special concern in South Bay), cadmium, copper, and zinc from water samples.

Progress: Monitoring sites at which suspended-solids concentrations are measured were operated at Point San Pablo, San Francisco pier 24 (Bay Bridge), San Mateo Bridge, Dumbarton Bridge, and channel marker 17 south of the Dumbarton Bridge. Two additional sites were established, one at Martinez and one at Mallard Island. Optical sensors at mid-depth and near-bottom were used to measure suspended-solids concentrations every 15 minutes at the sites. Servicing trips were made every 3 weeks to clean sensors and to collect water samples used to calibrate the sensors. A submersible instrument for measuring water velocity, pressure, and suspended-solids concentration in shallow water was deployed three times. The hydrodynamics of south San Francisco Bay were simulated to estimate water residence times. An interpretive report and a data report were written. The effects of sediment resuspension processes on dissolved-metals concentrations were evaluated by analyzing dissolved-solids concentrations of several metals.

Plans for Fiscal Year 1995: Maintenance of the monitoring sites will continue. Shallow-water instrumentation will be deployed. An additional site will be established at the Golden Gate Bridge. The residence time of sediment particles in South Bay will be estimated using numerical simulations of South Bay. An interpretive report and a data report will be published.

Reports:

Schoellhamer, D.H., 1994, Suspended solids concentrations in central San Francisco Bay during 1993 winter runoff (abs.): Eos, Transactions of the American Geophysical Union, v. 75, no. 3, Supplement, p. 122.

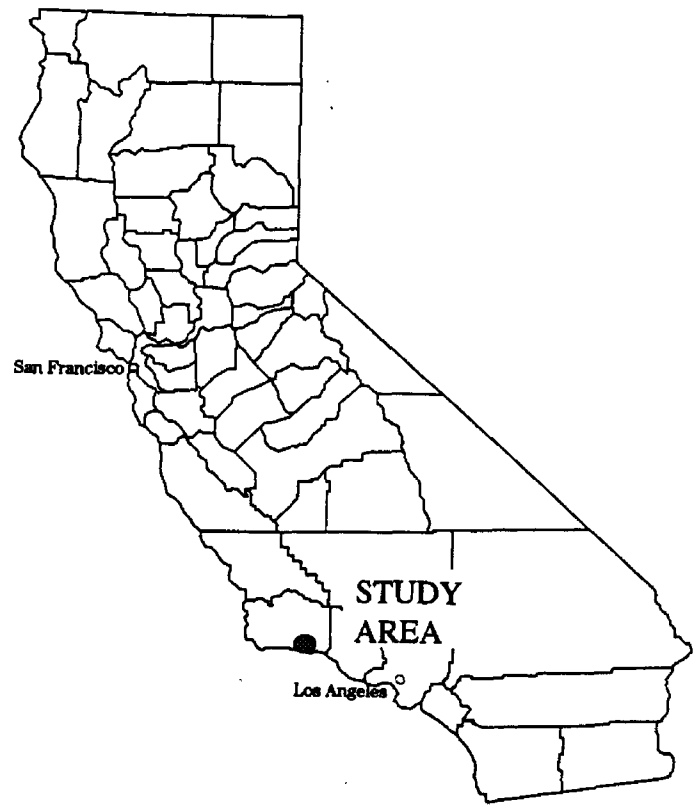
MULTIPLE-OBJECTIVE OPTIMIZATION APPLIED TO WATER-SUPPLY AND WATER-QUALITY PROBLEMS IN THE SANTA BARBARA AREA

Number: CA500

Cooperating Agency: Santa Barbara, City of

Project Chief: John R. Freckleton

Period of Project: April 1993 to March 1996



Problem: Santa Barbara relies chiefly on surface water to meet its water needs. However, reduced reservoir capacity owing to siltation and reduced surface-water supply during drought has necessitated increased ground-water extraction in the area. In addition, degradation of ground-water quality is occurring owing to seawater intrusion, upwelling of water high in dissolved solids into the freshwater aquifers, and migration of point-source pollutants into the ground-water system. Efficient water-management methods are needed to minimize the degradation of the water quality and to lessen the adverse economic effects.

Objectives: Demonstrate the use of multiple-objective optimization by addressing water-supply and water-quality problems in the Santa Barbara area. Develop methodology that allows water-management alternatives that entail multiple, and possibly conflicting objectives, to be investigated using flow and transport models coupled with multiple-objective optimization procedures. Extend, or develop, methods to link data, simulation models, and multiple-objective optimization.

Approach: Management goals and related legal and physical system constraints will be formulated mathematically as objective and constraint equations. Existing ground-water-flow and solute-transport models will be used directly or as simplified in regression relations to provide input data necessary for the optimization procedure. Multiple-objective optimizations problems will be solved by vector-maximization techniques. Acceptable solutions will be identified by a "filtering" process in which inferior solutions will be discarded. Sensitivity of solutions to changes in filtering parameters will be investigated.

Progress: Physical operational constraints were identified and cataloged for existing production-well and surface-water resources. Preliminary geographic information system (GIS) data bases were installed on the computer system of the consultant for the city of Santa Barbara. The data bases were updated to include geology, street, and land-parcel information. Electromagnetic induction data collected at several Santa Barbara area wells were analyzed. The analysis provided a basis for reconceptualizing the areal and vertical extent of the freshwater zones in Storage Unit III of the Santa Barbara ground-water basin. Geologic sections for Storage Units I and III were redrawn to conform to the new data, and appropriate changes were made to the areawide flow model. MODMAN, an optimization preprocessor used with the U.S. Geological Survey MODFLOW model, has been ported to the U.S. Geological Survey Data General workstation platform which is being used for the computer needs of this study. Changes were made to the SUTRA solute-transport model of Storage Unit I of the Santa Barbara ground-water basin on the basis of electromagnetic induction data for selected wells. Several steady-state and transient-state calibration runs were made using the SUTRA model. A two-objective problem (maximizing ground-water use and minimizing seawater intrusion) was solved in a single-objective framework by maximizing ground-water use and placing head-gradient constraints on the seawater boundary of the flow model (thus implicitly controlling seawater intrusion). Several single-objective optimization problems were solved using GAMS/MINOS (a preprocessor/optimization solver package) for scenarios that were based on the city of Santa Barbara's "Long-term water-supply alternatives analysis and urban water-management plan (April 1991)."

Plans for Fiscal Year 1995: Operational and legal constraints on the water-supply system will be updated. MODFLOW, MODMAN, and SUTRA will be ported and tested on the computer system to be used by the city of Santa Barbara. A user-friendly interface will be developed for the optimization of computer programs. Instruction manuals will be developed for city personnel. A linking procedure for the simulation-optimization model will be finalized. Writing of a report will begin.

Reports: None

GEOHYDROLOGY AND GROUND-WATER QUALITY OF THE WINCHESTER BASIN, RIVERSIDE COUNTY

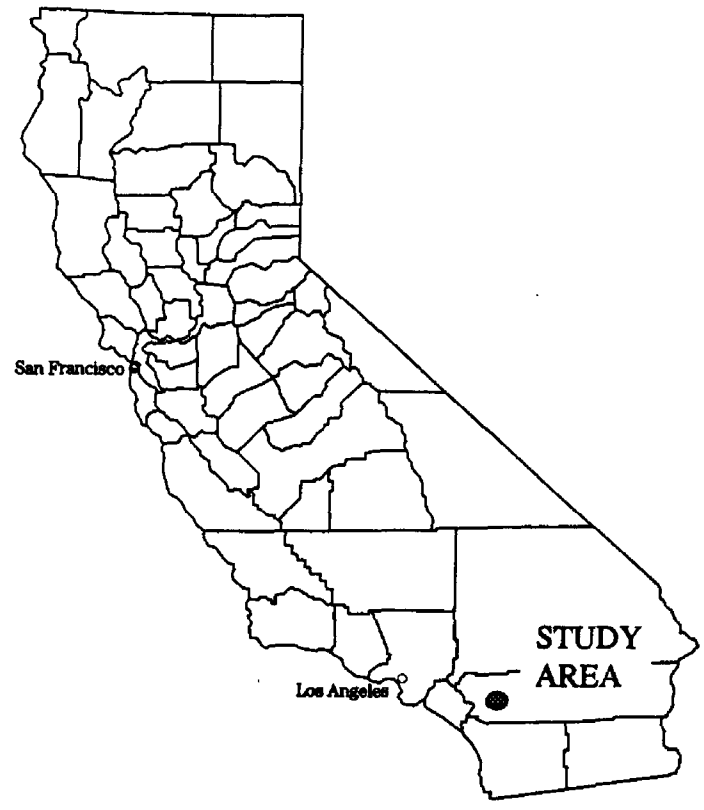
Number: CA501

Cooperating Agency: Eastern Municipal Water District

Project Chief: Terry F. Rees

Period of Project: October 1992 to September 1995

Problem: Poor quality ground water is moving from the Winchester basin into the southwest part of the Hemet basin, degrading the better quality water in that basin. Geohydrologic information about the Winchester basin is needed to formulate and evaluate plans for water-resources management in the area. At present, few data on the quantity, chemical quality, or movement of ground water are available for the study area, and little is known about the thickness, extent, and hydraulic properties of the aquifer in the Winchester basin and the characteristics of the boundary between the Winchester and Hemet basins.



Objectives: Develop an understanding of the geohydrology of the Winchester basin, particularly in the area adjacent to the Hemet basin. Determine (1) the geohydrologic properties of the aquifer, (2) the quantity of ground water in storage, (3) the horizontal and vertical definition of ground-water quality, (4) the direction of ground-water flow, and (5) the quantity of water moving from the Winchester basin into the Hemet basin.

Approach: The objectives of the study will be accomplished by collecting water-level and water-quality data from several existing well sites that are distributed aerially and vertically in the aquifer, by installing test holes to collect additional geologic and hydrologic data, and by determining hydraulic properties of the aquifer using aquifer tests. Depending on funding levels, a MODFLOW ground-water-flow model may be developed to test various management alternatives that would control water movement between the Winchester and Hemet basins.

Progress: All sites were completed and the wells developed. Water levels were measured and water-quality samples were collected and analyzed. Preliminary preparation for the aquifer tests were completed.

Plans for Fiscal Year 1995: Aquifer tests will be completed. The MODFLOW model will be refined. A final interpretive report will be prepared for submittal for Director's approval.

Reports: None

CALIFORNIA ARMY STORMWATER PROJECT

Number: CA502

Cooperating Agency: U.S. Army

Project Chief: Alan Stroppini

Period of Project: February 1993 to January 1994

Problem: In November 1990, new regulations were adopted for acquiring National Pollution Discharge Elimination System Stormwater Permits for municipalities and industrial facilities. The U.S. Army applied for a "group permit" through the U.S. Environmental Protection Agency to include all listed Army facilities throughout the Nation. California complied with the new regulations by issuing a General Industrial Stormwater Permit, which requires submittal of Stormwater Pollution Prevention Plans and Monitoring Plans. The Army requested the U.S. Geological Survey to assist them in the development of these plans.

Objectives: Assist the U.S. Army in the (1) determination of the need for regulatory exposure, (2) development of stormwater-pollution prevention plans (SWP3) and monitoring plans (MP), (3) development of procedures for submitting Notice of Intent, and (4) acquisition of general permits for seven U.S. Army facilities and nine U.S. Army Reserve facilities.

Approach: Initially, sites will be visited on all facilities and the need for regulatory exposure will be evaluated. For facilities requiring permits, SWP3s and MPs will be developed to provide information on potential sources of pollution to stormwater discharge, existing best-management practices, and recommendations for implementation of new best-management practices to improve the quality of the stormwater discharge. For facilities not requiring permits, the rationale will be documented. Assistance will be given for submitting a Notice of Intent. Additional sites will be visited and SWP3 documents will be developed as needed.

Progress: The project was terminated by the U.S. Geological Survey project coordinator and the U.S. Army in August 1994. No further work is anticipated.

Plans for Fiscal Year 1995: None. The project was terminated.

Reports: None

SACRAMENTO RIVER BASIN NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Number: CA504

Cooperating Agency: None. (U.S. Geological Survey Federal Program)

Project Chief: Joseph L. Domagalski

Period of Project: Continuing

Problem: Various human and natural processes can cause degradation of the quality of ground- and surface-water resources. To meet the needs for water-quality information at national, state, and local levels, the U.S. Geological Survey has implemented the National Water-Quality Assessment (NAWQA) program. This program will help determine the status of and trends in the quality of ground and surface water to identify factors that affect the quality of those resources. The Sacramento River Basin study unit is 1 of 60 study units in this national program.

Objectives: Describe current water-quality conditions consistent with the needs of the national synthesis; (2) define long-term trends (if any) in water-quality data; and (3) identify, describe, and explain to the extent possible the major human and natural factors that affect observed water-quality conditions and trends. Key factors of concern for the Sacramento River Basin include concentrations of pesticides, trace metals, and nutrients in surface and ground water. Biological issues of concern include endangered species of fish and the effects of various contaminants on fish populations.

Approach: During the first phase of this study, an extensive retrospective analysis of the status of and trends in water quality and aquatic ecology will be done using existing data. A reconnaissance will be done concurrently to collect data on aspects of water quality for which little or no data exist. These two activities will identify areas where there are insufficient data for water-quality assessment and will provide the basis for design of a 3-year intensive data-collection phase.

Progress: Activities during the first year of this project included the formation of a liaison committee to define major water-quality issues for this basin and to review specific aspects of the design of this project. Water-quality issues were listed and prioritized; these issues included pesticides in surface and ground water and trace metals from abandoned mines. Major issues also were listed and prioritized for fisheries in the Sacramento River; these include endangered species of fish populations and the effects of toxic substances on fish populations. A fact sheet, which provides a map of the basin and describes the water-quality issues, was published.

Plans for Fiscal Year 1995: Activities during the second year of this project will include work on a document detailing the design of water-quality monitoring activities in the study area and the completion of reports on available data for this basin.

Reports: None

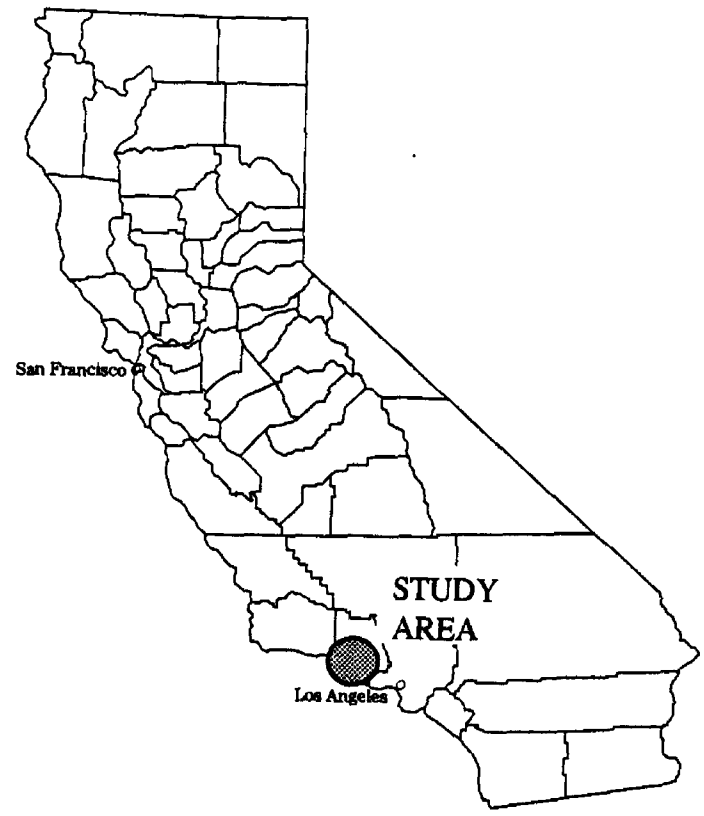
SANTA CLARA OPTIMIZATION

Number: CA505

Cooperating Agency: United Water Conservation District

Project Chief: Eric G. Reichard

Period of Project: October 1993 through September 1996



Problem: The Santa Clara River is the primary source of recharge to ground water in the Santa Clara-Calleguas basin. It is necessary to improve the understanding of the hydraulic and geochemical interaction of the Santa Clara River and the underlying aquifer system and to develop appropriate modeling tools to evaluate alternative surface- and ground- water management strategies.

Objectives: Develop a linked reservoir-operation and stream-aquifer optimization model to evaluate surface- and ground-water management strategies in the Santa Clara River valley. The model will explicitly consider streamflow uncertainty.

Approach: The study will include data collection, stream-aquifer simulation, and simulation-optimization modeling. Data collection tasks will include measurement and analysis of streamflow rates, ground-water levels, and surface- and ground-water quality for different streamflow conditions. The existing stream-aquifer simulation model will be refined in order to consider stream functioning on a more detailed time scale. Finally, a linked ground-water-management/reservoir-operation model will be constructed. The model will yield decision rules for operating surface-water facilities and will incorporate aspects of streamflow uncertainty.

Progress: Activities in fiscal year 1994 included data collection, data analysis, and preliminary modeling. Collection of surface-water data included periodic water-quality sampling and discharge measurements at approximately 20 locations on the Santa Clara River and its tributaries. These data were collected from the Santa Felicia Dam during periods with differing release rates. Three multicompletion monitoring sites (a total of 15 wells) were installed near the river. The wells were sampled for major ions, nutrients, stable isotopes of oxygen and hydrogen, tritium, and carbon isotopes. The wells have been instrumented with transducers and data loggers for continuous water-level measurement. In addition, transducers were installed directly in the Santa Clara River adjacent to two of the monitoring sites.

Evaluation of the surface-water data has provided information on where recharge and discharge are occurring along the river. Preliminary analysis of drilling, water-level, and water-quality data indicates that there is a limited connection between the river and the ground-water system in the Santa Paula basin and that the water in the deepest well in the Piru basin seems to be very different (isotopically lighter) water than water from all other monitoring wells in the study area.

Some of the river-discharge data were used for a simple calibration of the U.S. Geological Survey stream-routing model, DAFLOW. The model was run independently of any dynamic models of the ground-water system.

Plans for Fiscal Year 1995: Collection of surface- and ground-water data will continue. In October 1994, a dye-tracer test will be done in the Santa Clara River. All these data will be analyzed in order to develop improved understanding of the surface-water/ground-water interaction in the study area. These data will be incorporated into the southern California RASA ground-water-flow model and the stream-routing model. A linked stream-aquifer model will be developed to evaluate water-management options for the study area.

Reports: None

ENVIRONMENTAL FATE OF 1,2-DIBROMO-3-CHLOROPROPANE, SAN JOAQUIN VALLEY

Number: CA507

Cooperating Agency: University of California, Davis

Project Chief: Neil M. Dubrovsky

Period of Project: October 1993 to September 1995

Problem: Extensive areas of the sole-source aquifer in the eastern San Joaquin Valley have been contaminated by the soils fumigant 1,2-dibromo-3-chloropropane (DCBP). Although banned in 1979, the chemical persists in the subsurface environment. Contamination of wells with concentrations exceeding the mean concentration level of 0.2 parts per billion continues and has created a serious water-resource problem for a region that relies on ground water for its drinking-water supply.

Objectives: To define the physical and chemical processes that control DCBP transport and fate in ground water in the eastern San Joaquin Valley. Specific objectives are (1) to determine the influence of aquifer heterogeneity on DBCP movement using ground-water-flow and transport models and (2) to evaluate in situ chemical processes that control DBCP-degradation pathways and to determine the DBCP environmental half-life in the aquifer.

Approach: The approach integrates physical and chemical aspects of DBCP transport. A two-dimensional array of wells will be installed along a ground-water-flow path. A detailed hydrogeologic characterization of aquifer texture will be done using various techniques, including surficial and borehole geophysics. Stochastic methods will be used to incorporate the textural information into the ground-water-flow and transport models. A laboratory method will be developed to determine the concentration of a DBCP-degradation product. Age dating of the ground water will be done and the age data will be used with the concentrations of degradation products to estimate the half-life of the DBCP and to constrain the ground-water-flow model.

Progress: Eleven wells have been installed along a transect 3 miles in length in eastern Fresno County. Several wells were cored to determine texture. Water-quality samples were collected from all wells; the wells also were sampled for tritium and chlorofluorocarbon (CFC) to determine the age of the ground water. High-resolution surface-reflection seismics and surface (ground-penetrating radar) surveys were done along several lines to investigate the horizontal and vertical distribution of aquifer textures. Existing borehole and soil data also were collected and analyzed to evaluate textural distribution. Preliminary stochastic simulations of textural distribution have been done. A method for isolating and quantifying the concentration of the primary DBCP-degradation product (2-bromoallyl alcohol) has been developed.

Plans for Fiscal Year 1995: Additional wells will be drilled to fill in major gaps in current information. Ground-water-flow and transport simulations will be done using the stochasically generated distribution of texture. Model results of residence time will be calibrated using the age of the ground-water samples. Concentrations of the DBCP-degradation products in ground-water samples will be determined. The environmental half-life of DBCP will be estimated. The relative contribution of physical and chemical processes to the measured long-term gradual decline in DBCP concentration in the regional aquifer will be evaluated.

Reports: None

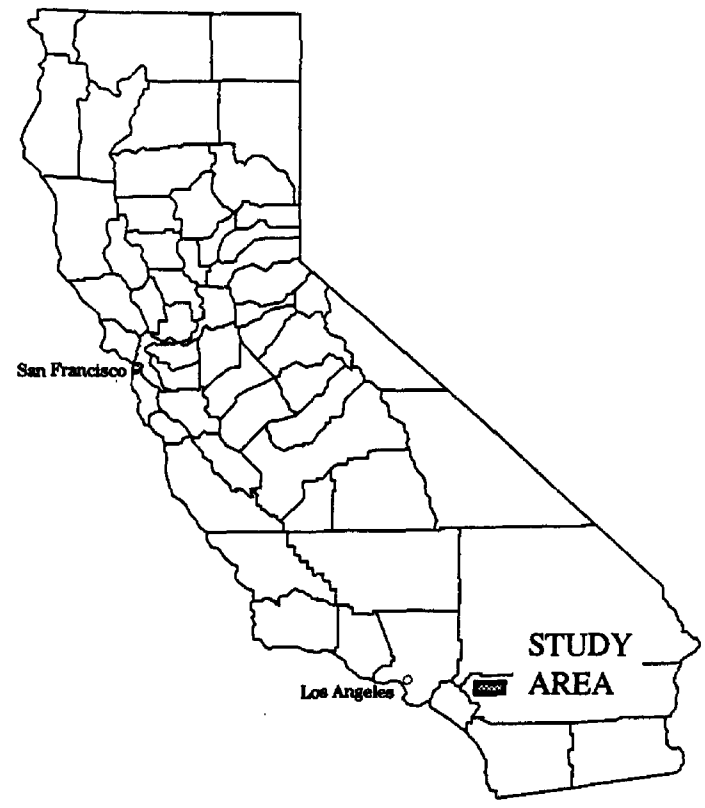
MARCH AIR FORCE BASE HYDROGEOCHEMISTRY

Number: CA509

Cooperating Agency: March Air Force Base

Project Chief: Terry F. Rees

Period of Project: October 1993 to December 1994



Problem: As a result of past handling and disposal of hazardous substances at March Air Force Base, these substances possibly may be migrating into the hydrologic system. Previous studies indicate a complex geology in the area; however, recharge, underflow, and aquifer layering in the area are poorly understood. To assess whether possible contamination is occurring, hydrogeologic conditions on and around the base need to be more clearly defined.

Objectives: Develop a detailed understanding of the geohydrologic conditions of the formations surrounding March Air Force Base. Evaluate the extent and thickness of water-bearing deposits. Determine the hydraulic characteristics of the alluvial deposits.

Approach: Existing data will be collected, evaluated, organized, and entered in a GIS data base. A well network will be established for water-level and water-quality monitoring. Aquifer-test sites will be selected and instrumented.

Progress: Data were collected for existing wells, and wells in the study area were canvassed.

Plans for Fiscal Year 1995: None. The project was terminated.

Reports: None

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